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MEASUREMENTS OF SOLAR RADIATION INTENSITY AND DETERMINATIONS OF ITS DEPLETION BY THE ATMOSPHERE WITH BIBLIOGRAPHY OF PYRHELIOMETRIC MEASUREMENTS

By HERBERT H. KIMBALL

[U. S. Weather Bureau]

In Procès-verbaux des séances de la Section de Météorologie, Union Géodésique et Géophysique Internationale, Annexe VI, Deuxième Assemblee Générale, the president of the section, Sir Napier Shaw, has given an excellent summary of pyrheliometric measurements of solar radiation intensity made in all parts of the world. The summary was prepared in response to a resolution of the section at its meeting in Rome in 1922.

Sir Napier expresses radiation intensities in units of power (kilowatts per square dekameter) for the reason, as he states, that "The kilowatt is the unit that engineers use to represent electrical power; solar energy is thereby brought into the same category as the energy which men buy or sell."

There are two kinds of solar radiation measurements to be considered, as follows:

(1) The total radiation received on a unit of horizontal surface from the sun and sky, and

(2) The intensity of solar radiation at normal incidence.

THE VERTICAL COMPONENT OF SOLAR RADIATION

Measurements of the total radiation as in (1) above are best made with recording instruments, and the records are continued during cloudy and rainy weather as well as when the sky is free from clouds. Table 1 gives a list of the stations at which continuous records of this character have been obtained. Figures 1 and 2 give the annual march of the daily totals for the different stations expressed in kilowatt hours per square dekameter.[1]

For all stations in the United States except Mount Weather, the data from which the curves are constructed is in the form of weekly means of the daily totals; for Mount Weather and Lourenco Marques the means are for decades; for all other stations they are monthly means. The weekly and decade means have been smoothed by the well-known smoothing formula

$$\frac{a+2b+c}{4}.$$

The sources of the data are given in Table 2.

TABLE 1.—*Stations which obtain records of the total radiation received on a horizontal surface from the sun and sky*

Station	Latitude	Longitude	Altitude	Period	Instruments
	° ′	° ′	*Meters*		
(1) Lincoln, Nebr.	40 50 N.	96 41 W.	381	July, 1915–December, 1925.	Callendar.
(2) Madison, Wis.	43 05 N.	89 23 W.	308	April, 1911–December, 1925.	Do.

[1] One gram-calorie per square centimeter equals 1.161 kilowatt hours per square dekameter.

TABLE 1.—*Stations which obtain records of the total radiation received on a horizontal surface from the sun and sky*—Continued

Station	Latitude	Longitude	Altitude	Period	Instruments
	° ′	° ′	*Meters*		
(3) Chicago, Ill. (University Station.)	41 47 N.	87 35 W.	210	September, 1923–April, 1927.	Weather Bureau thermo-electric.
(4) Mount Weather, Va.	39 04 N.	77 53 W.	540	May, 1912–September, 1914.	Callendar.
(5) Washington, D. C.	38 56 N.	77 05 W.	137	November, 1914–October, 1922.	Do.
				November, 1922–December, 1925	Weather Bureau thermo-electric.
(6) New York, N.Y. (Central Park Observatory.)	40 46 N.	73 58 W.	48	April, 1924–April, 1927.	Do.
(7) Habana, Cuba	23 09 N.	82 21 W.	40	March, 1925–May, 1926.	Do.
(8) Toronto, Canada	43 40 N.	79 24 W.	116		Callendar.
(9) Rothamsted, England.	51 48 N.	0 22 W.	128	1922–1924	Do.
(10) South Kensington, England.	51 30 N.	0 10 W.	37	1913–1920	Do.
(11) Davos Platz, Switzerland.	46 48 N.	9 49 E.	1,600	November, 1920–October, 1921.	Ångström.
(12) Arosa, Switzerland.[1]	46 47 N.	9 40 E.	1,860	1921–1925	Mi.; S. I.
(13) Lindenberg, Germany.[1]	52 13 N.	14 07 E.	106	1919	Robitzsch.
(14) Stockholm, Sweden.	59 21 N.	18 04 E.	44	July, 1922–June, 1923.	Ångström.
(15) Sloutzk (Pavlovsk), Russia.	59 41 N.	30 29 E.	40	1913–1919	Crova-Sawinoff.
(16) Lourenço Marques, Port; South Africa.	25 58 S.	32 26 E.	459	1915–1919	Callendar.
(17) Johannesburg, South Africa.	26 11 S.	28 04 E.	1,806	1908–June, 1910.	Do.

[1] Measurements of direct solar radiation only.

TABLE 2.—*Sources of data given in Figures 1 and 2*

(1) LINCOLN.

KIMBALL, HERBERT H. 1916–1925. Solar and sky radiation measurements. Mo. Wea. Rev., 44:178. Monthly thereafter. Washington.

(2) MADISON.

KIMBALL, HERBERT H. & MILLER, ERIC R. 1916. The total radiation received on a horizontal surface from the sun and sky at Madison, Wis. Mo. Wea. Rev., 44:180.

KIMBALL, HERBERT H. 1916–1925. Solar and sky radiation measurements. Mo. Wea. Rev. 44:179. Monthly thereafter. Washington.

(3) CHICAGO.

KIMBALL, HERBERT H. 1923–1927. Solar and sky radiation measurements. Mo. Wea. Rev. 51:533. Monthly thereafter. Washington.

(4) MOUNT WEATHER.

KIMBALL, HERBERT H. 1914. The total radiation received on a horizontal surface from the sun and sky at Mount Weather, Va. Mo. Wea. Rev. 42:474. Washington.

(5) WASHINGTON.

KIMBALL, HERBERT H. 1915–1925. The total radiation received on a horizontal surface at Washington, D. C. Mo. Wea. Rev. 43:100–111. Monthly thereafter. Washington.

(6) NEW YORK.

KIMBALL, HERBERT H. 1924–1927. Solar and sky radiation measurements. Mo. Wea. Rev. 52:225. Monthly thereafter. Washington.

(7) HABANA.
THEYE, CARLOS. Ms. tables.
(8) TORONTO.
SHAW, SIR NAPIER. 1926. Radiation in relation to meteorology. Procès-verbaux. Deuxème Assemblée Générale, Union Géodésique et Géophysique Internationale, Section de météorologie, p. 94. Rome.
(9) ROTHAMSTED.
SHAW, SIR NAPIER. 1926. Radiation in relation to meteorology. Proces-verbaux. Deuxième Assemblée Générale, Union Géodésique et Géophysique Internationale, Section de météorologie, p. 94. Rome.
(10) SOUTH KENSINGTON.
Great Britian. Meteorological Office, 1913–1920. British meteorological and magnetic year book, Part III (2), Geophysical Journal. London.
(11) DAVOS.
DORNO, C. 1922. Fortschritte in Strahlungmessungen. Met. Zeit. 1922, **39**:311, Tabelle 2. Braunschweig.
(12) AROSA.
GÖTZ, F. W. PAUL. 1926. Das Strahlungsklima von Arosa. Berlin.
(13) LINDENBERG.
ROBITZSCH, M. 1920–21. Einige Ergebnisse von Strahlungsregistrierungen, die im Jahre 1919 in Lindenberg gewonnen wurden. Beiträge zur Physik der freien Atmosphäre. Band IX, pp. 91–98. Leipzig.
(14) STOCKHOLM.
ÅNGSTRÖM, ANDERS. 1924. Solar and terrestrial radiation, Qr. Jr. Roy. Meteor. Soc., 1924, **50**:123, Table 1. London.
(15) SLOUTZK (PAVLOVSK).
RUSSIA. OBSERVATOIRE GÉOPHYSIQUE CENTRAL. 1926. Bulletin de la Commission Actinométrique permanent de l'observatoire géophysique central. 1925, No. 1–2, 1926, No. 1. Leningrad.
KALITIN, N. N. 1925. Die Wärmesummen der Sonnenstrahlung für Pavlovsk. Met. Zeit., **40**:355, Tabelle 2. Braunschweig.
(16) LOURENCO MARQUES. Provincia de Mocambique. Servicos de Marinha. 1916–1921. Relatonio do Observatorio Campos Rodriges em Lourenco Marques. Anno de 1915–1919. Lourenco Marques.
(17) JOHANNESBURG.
TRANSVAAL. METEOROLOGICAL DEP'T. 1907–1910. Annual Reports, Transvaal Observatory. Pretoria.

In Figure 1 the effect of latitude is shown by a comparison of the curves for Madison and Toronto with that for Habana, and the effect of altitude from a comparison of curves for Washington and Mount Weather. The curves for Chicago and New York show the screening effect of city smoke, especially during the cold months. The instruments in use at these American stations, except that for Toronto, have been standardized at the United States Weather Bureau by the method illustrated in the MONTHLY WEATHER REVIEW for May, 1923, 51: 242.

Since Figure 2 contains curves for stations in both the northern and southern hemispheres, in order to synchronize corresponding seasons of the year it is necessary to follow a different sequence of months for the two hemispheres, as shown. While we have no assurance that the instruments of different types in use at the different stations (see Table 1) record solar energy on precisely the same scale, the curves are generally in good accord. Thus, while Stockholm is farther north than the stations on the British Isles, it undoubtedly has clearer skies; therefore, the marked similarity between the curves for Stockholm, South Kensington, and Rothamsted is not surprising. The curves for Johannesburg and Lourenco Marques are in good agreement with that for Habana, but there is not the difference between the first two named that the difference in their elevations would lead us to expect. On the other hand, the curve for Davos Platz is so high as to indicate unusually clear skies.

For Sloutzk (Pavlovsk), Russia, two curves are given. One includes direct solar radiation only, the other both direct solar and diffuse sky radiation. The curves for Arosa and Lindenberg include only the direct solar radiation, that for Arosa as received upon a horizontal surface, and that for Lindenberg as received on a surface at right angles to the incident solar rays.

A comparison of the two curves for Sloutzk, and also that for Arosa with the curve for near-by Davos, indicates the very considerable part of the total solar thermal energy that is received diffusely from the sky, amounting in many months to 50 per cent. On the other hand, the curve for Lindenberg shows nearly as much energy received from the sun on a surface normal to its rays as the total energy received on a horizontal surface from the sun and sky at Davos, which is at a lower latitude and higher altitude.

For Stockholm Ångström (**1**) [2] found the ratios given in Table 3 between the total radiation and the sky radiation received on a horizontal surface.

TABLE 3.—*Ratio of sky radiation to the total radiation at Stockholm, expressed as a percentage—July, 1922–June, 1923*

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Per cent	79	74	42	35	33	35	26	36	45	54	77	97

From a summary published by me in the MONTHLY WEATHER REVIEW for October, 1924, 52: 475, Table 1, the relations given in Table 4 are found.

TABLE 4.—*Ratio of the sky radiation to the total radiation, as received on a horizontal surface with a cloudless sky, expressed as a percentage*

Station	Solar zenith distance												
	7.5°	25°	30°	48.3°	55°	60°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	85°
Washington, D. C.:													
Winter	----	----	----	12	----	16	20	23	25	29	32	37	----
Spring	----	10	----	13	----	17	20	24	28	32	35	40	----
Summer	----	19	----	21	----	24	27	31	34	37	38	40	----
Year	----	16	----	17	----	20	23	25	29	33	36	38	----
Lincoln	----	15	----	16	----	19	21	24	27	30	33	36	----
Madison	----	16	----	16	----	24	25	26	34	36	----	----	----
Flint Island	----	19	----	----	----	----	----	----	----	----	----	----	----
Hump Mountain	----	----	----	8	----	10	12	13	15	16	18	19	----
Mount Whitney	----	8	----	----	----	----	----	----	----	----	----	----	----
Mount Wilson [1]	14	14	14	16	20	20	24	27	----	32	----	38	55

[1] Measurements made in 1913.

Ångström (**1**) has found that the total radiation income Q_s during the day may be expressed by the formula $Q_s = Q_o\ (0.25 + 0.75S)$, where Q_o is the radiation income which corresponds to a cloudless sky, and S is the duration of sunshine expressed as a percentage of the possible duration. My own (**2**) studies of measurements made at Washington, Madison, and Lincoln give for this equation $Q_s = Q_o\ (0.22 + 0.78S)$.

The only difference between these two equations is in the term that represents the percentage of clear-sky radiation that penetrates a continuous cloud layer.

The average annual amounts of solar thermal energy received on a horizontal surface at the different stations is given in Table 5.

[2] The bold-face figures in parentheses refer to references at the end of the paper.

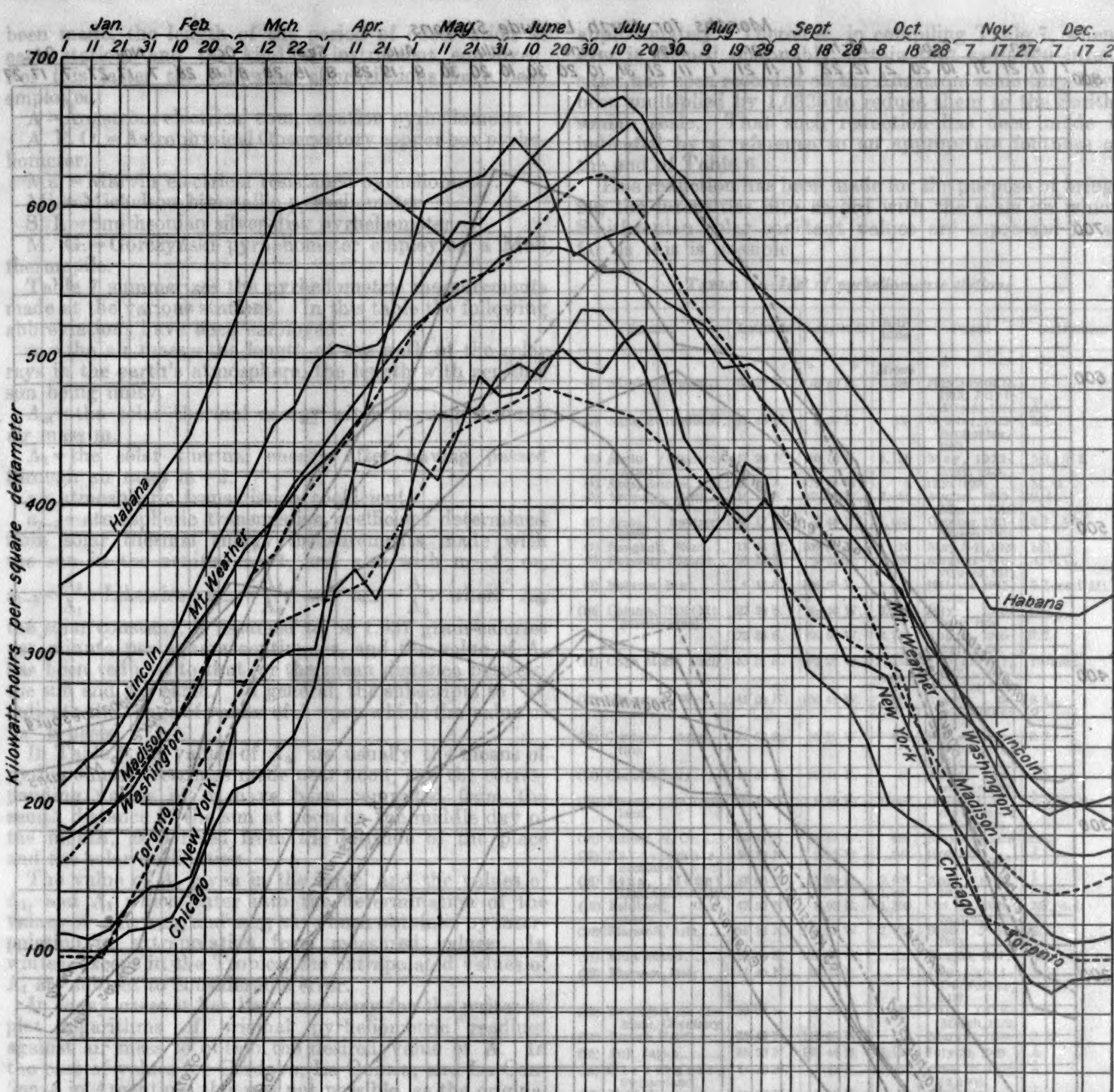

FIG. 1.—Annual march of daily totals of radiation received on a horizontal surface directly from the sun and diffusely from the sky (Western Hemisphere)

TABLE 5.—*Average annual amounts of solar thermal energy received on a square dekameter of horizontal surface*

Stations	Kilowatt-hours	Stations	Kilowatt-hours
Habana	184, 488	Lourenco Marques	169, 462
Lincoln	160, 906	Johannesburg	175, 606
Mount Weather	148, 824	Davos Platz	174, 043
Washington	145, 493	Rothamsted	83, 133
Madison	139, 523	South Kensington	78, 569
Toronto	106, 460	Stockholm	79, 267
New York	97, 856	Sloutzk	70, 296
Chicago	89, 424		

INTENSITY OF SOLAR RADIATION AT NORMAL INCIDENCE

Measurements of the intensity of solar radiation at normal incidence, (2) above, are usually made only when the sun is unobscured by clouds. They may be used to determine the total heat energy received directly from the sun with the sky cloudless, on either a horizontal surface, a surface normal to the incident rays, or a vertical or sloping surface facing in any desired direction (3), (4). However, such determinations have not the meteorological significance that attaches to continuous records under all sorts of weather conditions.

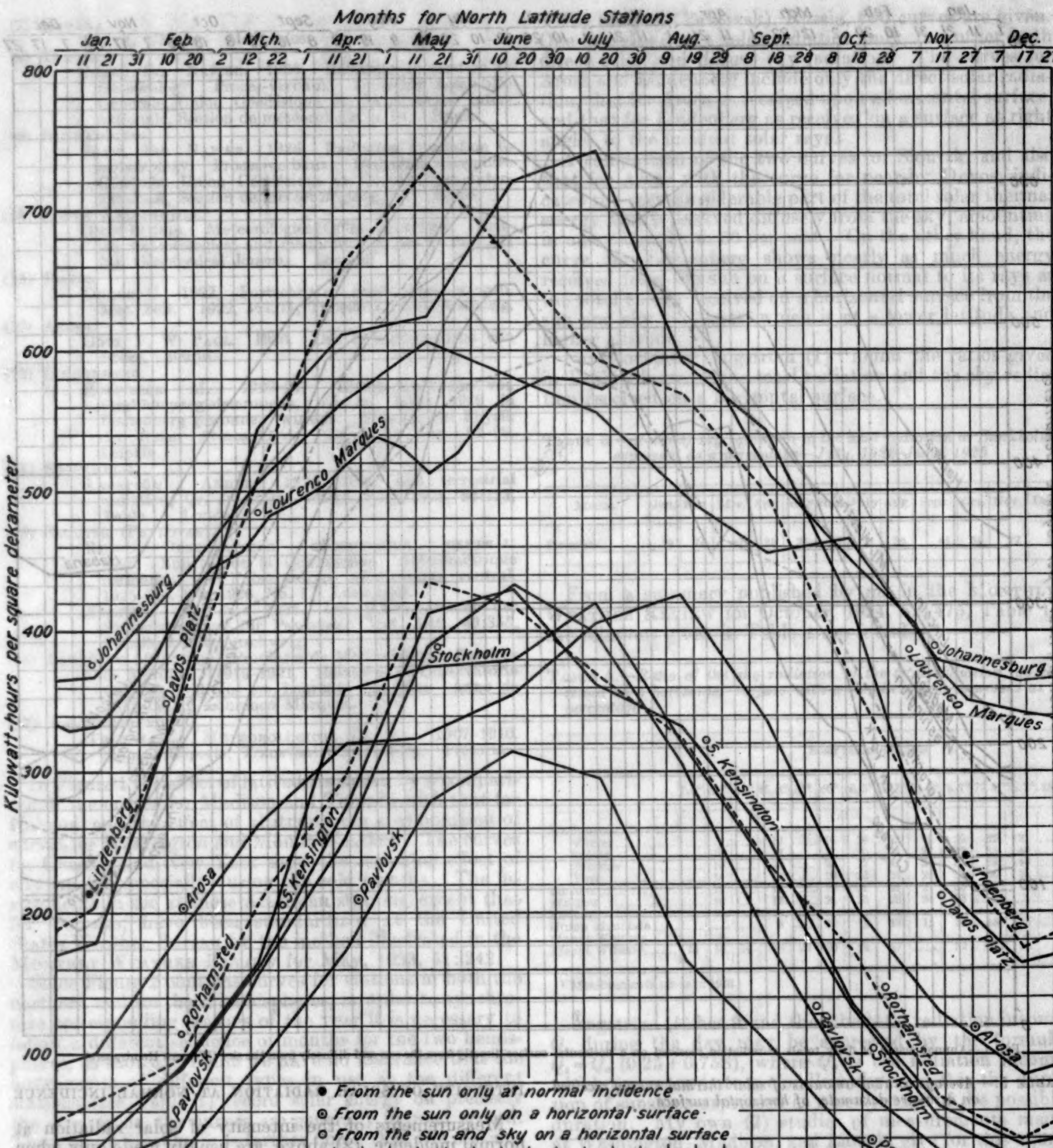

FIG. 2.—Annual march of daily totals of radiation (Eastern Hemisphere)

In this paper these measurements will be used in conjunction with the mean value of the solar constant, as determined by the Astrophysical Observatory of the Smithsonian Institution, in a study of the atmospheric transmission of solar radiation, or its complement, atmospheric depletion.

Table 6 gives a list of stations at which pyrheliometric measurements of the intensity of solar radiation have

been made, the length of the period of observation at each station, and the kind of instrument employed. For this latter the following abbreviations have been employed:

A = Ångström electrical compensation pyrheliometer.

A. P. O. = Astrophysical Observatory copper box pyrheliometer.

Ma. = Marvin electrical resistance pyrheliometer.

Mi. = Michelson bimetallic pyrheliometer.

S. I. = Smithsonian silver-disk pyrheliometer.

M. G. = Gorczyński pyrheliometer employing a Moll thermopile.

Table 7 summarizes the pyrheliometric measurements made at the various stations. In this table the following abbreviations have been employed:

m = the air mass = the length of the path of the solar rays in the earth's atmosphere, the length with zenithal sun being unity.

A_m = the solar thermal energy after passing through air mass m.

A_2 = the solar thermal energy after having passed through air mass m = 2.

a = atmospheric transmission coefficient.

a_{1-2} = atmospheric transmission coefficient determined from solar thermal energy measurements made with the sun in the zenith, m = 1, and also with m = 2; or, $a_{1-2}=\frac{A_2}{A_1}$. Likewise, $a_{2-3}=\frac{A_3}{A_2}$, and $a_{0-1}=\frac{A_1}{A_0}$, where A_0, the solar constant, is assumed to be 1.937 gram-calories per minute per square centimeter, and the value of A_1 has been reduced to that for the mean distance between the sun and the earth. In general, the subscripts to "a" indicate the range of values of A upon which the value of "a" is based.

In Table 7 the values of A_m are usually the means of pyrheliometric readings made near noon, and the corresponding values of m have been computed from the zenith distance of the sun at noon on the middle day of the month, as derived from the latitude of the place and the solar declination.

The value of A_2 given in the table, and the values of A_1, and A_3 which enter into the determination of the values of a_{0-1}, a_{1-2}, and a_{2-3}, have been obtained by interpolation or extrapolation from measured values. In winter, except in the Tropics, the extrapolated values of A_1 are subject to considerable error.

In many cases it has been necessary for the writer to plot logarithms of original pyrheliometric readings against air mass to obtain the desired value of A. In the case of values for Cordoba, La Quiaca, and La Confianza in Argentina, this was not possible, as the original readings are not accessible to me. I have therefore made use of the published values of A_1 and "a," and from these have computed A_2.

Values of A in the table are expressed in gram-calories per minute per square centimeter of normal surface. They have not been reduced to mean distance between the earth and sun.

The A. P. O., the S. I., and the Ma. pyrheliometers have been intercompared to permit of bringing their readings into conformity with the Smithsonian pyrheliometric scale of 1913 (5). The Mi. pyrheliometer is a secondary intrument that is standardized by comparison with a standard instrument, most frequently the Ångström. It has been shown (6) that the ratio

$$\frac{\text{Smithsonian scale}}{\text{Ångström scale}}=1.0325,$$

approximately. Therefore, in compiling Table 7, whenever it seemed reasonably certain that radiation intensities had been recorded on the Angström scale they have been multiplied by 1.0325 to reduce them to the Smithsonian scale. That such reduction has been made is indicated by a reference to an appropriate footnote at the end of Table 6.

This reduction has been made for the purpose of bringing the intensities into accord with the scale on which Smithsonian solar constant values are expressed in so far as this is possible.

TABLE 6.—*List of pyrheliometric stations*

Station	Latitude	Longitude	Altitude	Period	Instrument
	° ′	° ′	*Meters*		
(1) Abisko, Sweden	68 21 N.	18 49 E.	390	July 2–Sept. 13, 1913; July 1–Aug. 21, 1914.	Å.[1]
(2) Agra, Switzerland	45 48 N.	9 00 E.	550	October, 1922–September, 1923.	Mi.
(3) Algäu (Riezlern), Austria.	47 22 N.	10 10 E.	1,150	May, 1922–May, 1924.	Mi., S. I.
(4) Apia, Samoa	13 48 S.	171 46 W.	2	1925–1927	M. G.
(5) Arequipa, Peru	16 22 S.	63 05 W.	2,451	August, 1912–March, 1915.	S. I.
(6) Arosa, Switzerland.	46 17 N.	9 40 E.	1,860	October, 1921–March, 1925.	S. I., Mi.
(7) Bangkok, Siam	13 44 N.	100 30 E.	10	May 5–21, 1923	Mi.[1]
(8) Bassour, Algeria	36 13 N.	2 52 E.	1,160	August–November, 1911.	A. P. O.
(9) Batavia, Java	6 11 S.	106 50 E.	8	1915 and 1917–1919.	S. I. and Mi.
(10) Calama, Chili (Mt. Montezuma).	22 28 S.	68 56 W.	2,250	July, 1918–July, 1920.	S. I.
	22 38 S.	68 56 W.	2,700	August, 1920–April 1926.	S. I.
(11) Cape Horn, Chili.	55 31 S.	70 25 W.	12	September, 1882 – September, 1883.	Pouillet.
(12) Cheyenne, Wyo	41 08 N.	104 48 W.	1,856	August 29–September 3, 1910.	S. I.
(13) Cordoba, Argentina.	31 25 S.	64 12 W.	438	February, 1912–June, 1914.	S. I.
(14) Corleto, Italy	44 36 N.	10 51 E.	58	Agust–September, 1898.	Å.[1]
(15) Davos, Switzerland.	46 48 N.	9 49 E.	1,600	1912–1918 (reduced to S. I. scale, 1913).	Å and Mi.
(16) Ellijay, N. C.	35 11 N.	85 15 W.	683	May 8–13, 1916	S. I.
(17) Eskdalemuir, Scotland.	55 19 N.	3 12 W.	244	1909–1921	Å.[1]
(18) Etna, Mount (Casa Cantoniera)	37 45 N.	15 00 E.	2,950 1,885	Aug. 18–23, 1908.	Å.[1]
(19) Feldberg, Germany.	47 52 N.	8 02 E.	1,300	Oct. 19, 1921–March, 1925.	Mi., S. I.
(20) Flagstaff, Ariz.	35 12 N.	111 37 W.	2,105	Sept. 25–30, 1910.	S. I.
(21) Flint Island	10 05 S.	152 10 W.	-------	Dec. 29, 1907	S. I.
(22) Florence, Italy	43 46 N.	11 13 E.	73	June, 1915–December, 1917.	Å.[1]
(23) Frankfort on the Main, Germany.	50 07 N.	8 38 E.	820	July, 1919–March, 1922.	Mi.[1]
(24) Fresno, Calif.	36 43 N.	119 49 W.	110	Mar., 14, 1920	S. I.
(25) Fuji, Japan	35 22 N.	138 44 E.	3,726	July 29, 1909	Å.[1]
(26) Gornergrat, Switzerland.	45 59 N.	7 47 E.	3,136	June 25–July 12, 1903.	Å.[1]
(27) Hald, Denmark	56 23 N.	9 19 E.	78	1902–1903	Å.[1]
(28) Helwan (Cairo), Egypt.	29 52 N.	31 20 E.	116	February, 1914–December, 1923.	Å.[1]
(29) Hump Mountain, N. C.	36 08 N.	82 00 W.	1,500	June, 1917–March, 1918.	S. I.
(30) Innsbruck, Austria.	47 16 N.	11 23 E.	580	January–June, 1908.	Å.[1]
(31) Johannesburg, South Africa.	26 11 S.	28 04 E.	1,806	April, 1907–June, 1911.	Å[1].
(32) Jungfraujoch, Switzerland.	46 32 N.	7 58 E.	3,457	Sept. 23–Oct. 3, 1923.	Å, Mi.
(33) Karlsruhe, Germany.	49 01 N.	8 25 E.	128	Sept. 6, 1921–Mar. 31, 1925.	Mi., S. I.
(34) Katharinenburg, Russia.	56 50 N.	60 39 E.	290	1896–1898	Chwolson.
(35) Kew Observatory, England.	51 28 N.	0 18 W.	6	1911–1921	Å.[1]
(36) Kief, Russia	50 24 N.	30 28 E.	183	1888	Crova.
(37) Kolberg, Germany	54 11 N.	15 33 E.	2	April, 1914–April, 1915.	Å, Mi.[1]
(38) La Confianza, Argentina.	22 08 S.	65 45 W.	4,483	August–September, 1913.	S. I.
(39) La Jolla, Calif.	32 50 N.	117 15 W.	30	Mar. 2–4, 1920	S. I.
(40) La Quiaca, Argentina.	22 08 S.	65 45 W.	3,492	September, 1912–October, 1913.	S. I.

[1] Radiation intensities as recorded have been reduced to the Smithsonian pyrheliometric scale of 1913 by multiplying by 1,0325.

TABLE 6.—*List of pyrheliometric stations*—Continued

Station	Latitude	Longitude	Altitude	Period	Instrument
	° ′	° ′	*Meters*		
(41) Lausanne, Switzerland.	46 31 N.	6 38 E.	515	1806-1902	Crova.
(42) Leningrad (St. Petersburg), Russia.	59 56 N.	30 15 E.	5	1895-1904	Chwolson.
(43) Lincoln, Nebr.	40 50 N.	96 41 W.	373	July, 1915–December, 1925.	Ma.
(44) Lindenberg, Germany.	52 13 N.	14 07 E.	106	1919	Mi. and Robitzsch.
(45) Madison, Wis.	43 05 N.	89 23 W.	297	July, 1910–December, 1925.	Ma.
(46) Madrid, Spain	40 24 N.	3 41 E.	655	September, 1910–August, 1924.	Å.[1]
(47) Medford, Oregon	42 20 N.	122 40 W.	408	Mar. 28–Apr. 5, 1920.	S. I.
(48) Modena, Italy	44 39 N.	10 56 E.	51	March–November, 1900; July–September, 1901; January, 1902–June, 1903.	Å.[1]
(49) Mont Blanc, France.	45 49 N.	6 52 E.	4,810	August and September, 1904.	Crova actinograph.
(50) Monte Cimone, Italy.	44 12 N.	10 42 E.	2,165	August, 1899; August, 1900; July–September, 1901; July–August, 1902; July–September, 1903; July–August, 1904; July–August, 1905.	Violle and A.[1]
(51) Monte Rosa, Italy	45 55 N.	7 56 E.	4,560	August, September, 1905, 1906, 1907.	Å.[1]
(52) Montpellier, France	43 36 N.	3 53 E.	43	1883–1900	Crova.
(53) Moscow, Russia	55 45 N.	37 34 E.	156	May–August, 1921.	Michelson compared with Å.[1]
(54) Mount Czarnohora, Poland (Eastern Carpathians):					
Worchta	48 18 N.	24 34 E.	770	August, 1924	Å, S. I.
Jablonica	48 19 N.	24 29 E.	840	do	Å, S. I.
Pożyżewska	48 10 N.	24 33 E.	1,372	September, 1909.	Å, S. I.
			1,406	July, August, 1924.	Å, Mi, S. I.
Chomiak	48 22 N.	24 30 E.	1,544	August, 1924	Å, S. I.
Pożyżewska	48 09 N.	24 32 E.	1,882	do	Å, S. I.
Howerla	48 10 N.	24 30 E.	2,058	do	Å, Mi, S. I.
(55) Mount Weather, Va.	39 04 N.	77 53 W.	540	September, 1907–September, 1914.	Ma.
(56) Mount Whitney, Calif.	36 35 N.	118 17 W.	4,420	August, 1908, September, 1909, September, 1910.	A. P. O.
(57) Mount Wilson, Calif.	34 13 N.	118 04 W.	1,737	1905–1920	A. P. O.
(58) Naples, Italy	40 52 N.	14 15 E.	149	December, 1913–January, 1915.	Å.[1]
(59) Nijni-Oltchedaeff, Russia.	48 38 N.	27 40 E.	197	1912–1914	Å.[1]
(60) Numazu, Japan	35 06 N.	138 51 E.	10	July 29, 1909	Å.[1]
(61) Nyköping, Sweden.	58 45 N.	17 01 E.	18	March, 1918–May, 1919.	Å.[1]
(62) Pangerango, Java	6 50 S.	106 50 E.	3,030	June - July, 1915; July–August, 1919.	Mi.[1]
(63) Paris (Parc St. Maur), France.	48 49 N.	2 29 E.	50	1907–1923	Å.[1]
(64) Pavlovsk (Sloutzk, Russia).	59 41 N.	30 29 E.	40	September, 1892–December, 1919; January, 1925–April, 1926.	Crova - Sawinoff, Mi.
(65) Phoenix, Ariz.	33 28 N.	112 00 W.	350	Oct. 3–8, 1910	S. I.
(66) Pomona, Calif.	34 03 N.	117 45 W.	265	Feb. 26–28, 1920.	S. I.
(67) Potsdam, Germany.	52 23 N.	13 04 E.	106	March, 1907–December, 1915.	Mi, Å, S. I.
(68) Red Bluff, Calif.	40 10 N.	122 15 W.	110	Mar. 23–25, 1920.	S. I.
(69) St. Blasien, Germany.	47 46 N.	8 08 E.	790	June, 1919–March, 1920; 1921–1925.	Mi., S. I.
(70) Santa Fe, N. Mex.	35 41 N.	105 57 W.	2,138	September, 1910; October, 1912–March, 1922.	Ma.
Twin Mountain.	35 39 N.	105 55 W.	2,438	Oct. 25, 1912	S. I.
Lake Peak	35 48 N.	105 45 W.	3,720	Oct. 29, 1912	S. I.
(71) Sestola, Italy	44 15 N.	10 46 E.	1,092	July–September, 1899; July–August, 1900; July–September, 1921.	Å and Violle.[1]
(72) Simla, India	31 07 N.	77 08 E.	2,204	October, 1906–December, 1915.	Å.[1]
(73) Smeroe, Java	8 00 S.	112 55 E.	3,670	Apr. 30, 1915, and Aug. 25, 1918.	Mi.[1]
(74) Sonnblick, Austria	47 03 N.	12 56 E.	3,106	June 19–July 17, 1902.	Å.[1]
(75) Tashkent, Russia	41 20 N.	69 18 E.	......	January–April, 1926.	Mi.
Teneriffe, Canary Islands:					
(76) Pic de Teyde	28 12 N.	16 42 W.	3,683	June 25–27, 1896.	Å.[1]
(77) Alta Vista	28 12 N.	16 42 W.	3,252	June 21–July 3, 1896.	Å.[1]
(78) Izana	28 19 N.	16 30 W.	2,367	April–December, 1916.	S. I.
(79) Cañadas	28 13 N.	16 34 W.	2,100	May, 1912 – June, 1915.	S. I.
(80) Guimar	28 18 N.	16 28 W.	360	July 2–3, 1896	Å.[1]
(81) Théodosie, Russia	45 02 N.	35 24 E.	......	January, 1925 – April, 1926.	Mi.
(82) Tjisoeroepan, Java	6 50 S.	109 30 E.	1,200	July, 1918	Mi.[1]
(83) Trapp, Va.	39 04 N.	77 52 W.	220	Aug. 30–Sept. 2, 1909.	A. P. O.
(84) Treurenberg, Spitzbergen.	79 55 N.	16 52 E.	9	September, 1899; April–July, 1900.	Å.[1]
(85) Upsala, Sweden	59 51 N.	17 32 E.	40	1901	Å.[1]
(86) Ursanova, Poland	52 02 N.	21 00 E.	100	June–August, 1909.	Å.[1]
(87) Wahnsdorf, Germany.	51 07 N.	13 41 E.	260	August, 1917–August, 1918	Mi.
(88) Warsaw, Poland	52 15 N.	21 02 E.	120	1010–1918	Å and others.[1]
(89) Washington, D. C.	38 56 N.	77 05 W.	127	October, 1914–December, 1925.	Ma.
(90) Zakopane, Austria	49 18 N.	19 58 E.	899	August–September, 1903.	Å.[1]
MISCELLANEOUS					
(91) Atlantic Ocean	38 N.	10 W.	......	Mar. 8, 1923	Mi.[1]
(92) Mediterranean Sea	36 N.	50 E.	......	Mar. 13, 1923	Mi.[1]
	32 N.	32 E.	......	Aug. 5, 1923	Mi.[1]
	34 N.	24 E.	......	Aug. 7, 1923	Mi.[1]
	38 N.	16 E.	......	Aug. 9, 1923	Mi.[1]
(93) Suez Canal	30 N.	33 E.	......	Mar. 18, 1923	Mi.[1]
(94) Red Sea	22 N.	38 E.	......	Mar. 20, 1923	Mi.[1]
	18 N.	40 E.	......	July 31, 1923	Mi.[1]
	22 N.	38 E.	......	Aug. 1, 1923	Mi.[1]
(95) Gulf of Aden	12 N.	44 E.	......	Mar. 23, 1923	Mi.[1]
	11 N.	47 E.	......	July 28, 1923	Mi.[1]
(96) Indian Ocean	10 N.	65 E.	......	Mar. 28, 1923	Mi.[1]
	4 N.	61 E.	......	July 22, 1923	Mi.[1]
(97) Gulf of Siam	3 N.	101 E.	......	Apr. 10, 1923	Mi.[1]
OBSERVATIONS FROM BALLOONS					
(98) Omaha, Nebr.	41 16 N.	95 56 W.	22,000	July 11, 1914	S. I. registering.
(99) Griesheim, Germany.	51 07 N.	8 41 E.	7,505	Oct. 19, 1913	Å.[1]

[1] Radiation intensities as recorded have been reduced to the Smithsonian pyrheliometric scale of 1913 by multiplying by 1.0325.

TABLE 7.—*Monthly means of solar radiation and atmospheric transmission*

Stations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
La Confianza (38):												
A_2								1.59				
a_{1-2}								.928				
a_{0-1}								.899				
La Quiaca (40):												
A_2	1.44	1.41	1.41	1.48	1.53	1.54	1.57	1.51	1.51	1.49		
a_{1-2}	.879	.869	.887	.900	.912	.911	.916	.908	.900	.891		
a_{0-1}	.818	.818	.813	.855	.880	.903	.916	.882	.874	.855		
Calama (10):												
A_2	1.43	1.42	1.40	1.41	1.44	1.43	1.41	1.45	1.46	1.47	1.43	1.45
a_{2-3}	.894	.894	.887	.898	.912	.908	.902	.902	.902	.900	.894	.890
a_{0-1}	.790	.799	.795	.815	.827	.834	.824	.842	.837	.832	.811	.816
Mount Montezuma:												
A_2	1.47	1.43	1.45	1.46	1.48	1.48	1.47	1.47	1.49	1.51	1.51	1.49
a_{2-3}	.901	.891	.902	.910	.918	.920	.921	.916	.915	.912	.909	.900
a_{0-1}	.813	.815	.825	.845	.859	.859	.862	.855	.857	.857	.846	.832
Arequipa (5):												
A_2	1.30	1.33	1.33	1.31	1.33	1.35	1.33	1.32	1.31	1.32	1.33	1.32
a_{1-2}	.832	.880	.878	.870	.880	.883	.865	.865	.850	.845	.843	.835
a_{0-1}	.778	.759	.775	.783	.796	.818	.820	.808	.806	.801	.795	.792
Cordoba (13):												
A_2	1.15	1.18	1.16	1.25	1.25	1.24	1.21	1.26	1.19	1.18	1.22	1.21
a_{1-2}	.800	.824	.825	.853	.863	.863	.852	.860	.825	.820	.835	.831
a_{0-1}	.720	.720	.722	.763	.770	.770	.756	.778	.748	.741	.736	.728
Cape Horn (11):												
A_m	1.48	1.37	0.99	1.09	0.88	0.96	0.93	0.88	1.39	1.36	1.25	1.37
m	1.28	1.36	1.75	2.50	3.51	5.54	3.30	3.10	1.62	1.50	1.33	1.22
Mount Whitney (56):												
A_2								1.56				
a_{2-3}								.927				
a_{0-1}								.893				
Mount Wilson (57):												
A_2					1.33	1.35	1.33	1.33	1.38	1.42	1.46	
a_{1-4}					.881	.893	.888	.891	.895	.903	.915	
a_{0-1}					.795	.795	.795	.792	.795	.796	.796	
Hump Mountain (29):												
A_2	1.52	1.43	1.46			1.29	1.12	1.24	1.36	1.38	1.41	1.46
a_{1-2}	.918	.905	.917					.857	.902	.808	.900	.916
a_{0-1}	.828	.799	.813					.765	.786	.788	.814	.814
Santa Fe (70):												
A_2	1.51	1.46	1.43	1.34	1.30	1.24	1.22	1.25	1.32	1.38	1.45	1.49
a_{2-3}	.913	.897	.903	.873	.908	.871	.885	.880	.886	.899	.912	.893
a_{0-1}	.825	.822	.814	.801	.803	.783	.766	.767	.798	.811	.813	.834
Lake Peak:												
A_2										1.34		
a_{2-3}										.847		
a_{0-1}										.802		
Twin Mountain:												
A_2										1.38		
a_{2-3}										.848		
a_{0-1}										.808		
Flagstaff (20):												
A_2									1.40			
a_{1-4}									.884			
a_{0-1}									.817			
Cheyenne (12):												
A_2								1.26				
a_{1-4}								.850				
a_{0-1}								.765				
Phoenix (65):												
A_2										1.27		
a_{1-4}										.875		
a_{0-1}										.753		
La Jolla (39):												
A_2			1.32									
a_{2-3}			.871									
a_{0-1}			.782									
Pomona (66):												
A_2		1.30										
a_{2-3}		.850										
a_{0-1}		.805										
Fresno (24):												
A_2			1.34									
a_{2-3}			.869									
a_{0-1}			.776									
Red Bluff (68):												
A_2			1.32									
a_{2-3}			.845									
a_{0-1}			.772									
Medford (47):												
A_2			1.24									
$a_{1.5-2.5}$			.857									
a_{0-1}			.778									
Lincoln, Nebr.(43):												
A_2	1.35	1.37	1.28	1.20	1.13	1.09	1.07	1.07	1.17	1.27	1.36	1.37
a_{2-3}	.874	.870	.844	.821	.842	.837	.829	.841	.849	.866	.875	
a_{0-1}	.772	.793	.789	.750	.734	.719	.706	.682	.725	.752	.784	
Madison, Wis.,(45):												
A_2	1.36	1.37	1.31–	1.22	1.09	1.09	1.04	1.09	1.16	1.19	1.30	
a_{1-3}	.893	.883	.870	.865	.801	.833	.798	.831	.879	.868	.890	
a_{0-1}	.776	.782	.779	.734	.718	.704	.680	.692	.720	.706	.736	
Washington, D. C. (89):												
A_2	1.22	1.17	1.14	1.07	0.99	0.89	0.91	0.95	1.04	1.11	1.17	1.22
a_{2-3}	.825	.829	.826	.823	.816	.800	.849	.839	.829	.838	.841	.842
a_{0-1}	.742	.744	.731	.702	.676	.643	.626	.646	.688	.719	.702	.726
Mount Weather, Va. (55):												
A_2	1.34	1.25	1.23	1.17	0.99	1.03	0.99	1.05	1.14	1.13	1.26	1.30
a_{2-3}	.861	.847	.833	.788	.775	.820	.777	.826	.830	.819	.866	.860
a_{0-1}	.778	.743	.755	.774	.675	.670	.680	.673	.71	.707	.734	.755

TABLE 7.—*Monthly means of solar radiation and atmospheric transmission*—Continued

Stations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Trapp, Va. (83):												
A_2									1.07			
$a_{1.5-2.5}$									.750			
a_{0-1}									.748			
Ellijay, N. C.(16):												
A_2					1.21							
a_{1-2}					.846							
a_{0-1}					.754							
Teneriffe:												
Pic de Teyde (76)—												
A_2						1.53						
a_{1-2}						.911						
a_{0-1}						.897						
Alta Vista (77):												
A_2						1.51						
a_{1-2}						.905						
a_{0-1}						.887						
Izana (78):												
A_m				1.61	1.62	1.61	1.54	1.55	1.57	1.59	1.59	1.65
m				1.04	1.02	1.01	1.01	1.04	1.12	1.25	1.45	1.61
Cañadas (79):												
A_2	1.47	1.51	1.49	1.45	1.41	1.39	1.37	1.37	1.42	1.42	1.44	1.51
a_{1-2}	.875	.896	.897	.904	.887	.886	.879	.875	.888	.877	.883	.891
a_{0-1}	.839	.849	.851	.863	.840	.837	.853	.836	.834	.830	.822	.845
Guimar (80):												
A_2							1.22					
a_{1-2}							.841					
a_{0-1}							.771					
Madrid, Spain, (46):												
A_m	1.23	1.26	1.34	1.36	1.33	1.30	1.20	1.26	1.28	1.27	1.23	1.16
m	2.08	1.68	1.34	1.16	1.07	1.05	1.06	1.12	1.26	1.53	1.94	2.25
Monte Rosa, Italy, (51):												
A_2									1.56			
a_{1-2}									.908			
a_{0-1}									.900			
Monte Cimone (50):												
A_2								1.26				
a_{1-4}								.871				
a_{0-1}								.764				
A_m							1.44	1.42	1.60			
m							1.22	1.28	1.50			
Sestola (71):												
A_m							1.38	1.37	1.32			
m							1.20	1.24	1.30			
Etna (Mount) (18):												
A_2								1.43				
a_{1-2}								.920				
a_{0-1}								.823				
Casa Cantoniera:												
A_2								1.37				
a_{1-2}								.906				
a_{0-1}								.800				
Florence (22):												
A_m	1.04	1.12	1.29	1.21	1.21	1.21	1.20	1.15	1.14	1.11	1.03	1.01
m	2.33	1.77	1.42	1.19	1.10	1.06	1.08	1.15	1.32	1.65	2.14	2.56
Corleto (14):												
A_m								1.28	1.27			
m								1.17	1.27			
Modena (48):												
A_m	1.10	1.01	1.23	1.18	1.24	1.16	1.19	1.23	1.14	1.22	1.15	1.05
m	2.41	1.86	1.45	1.22	1.11	1.07	1.09	1.17	1.33	1.68	2.21	2.65
A_2							1.01	0.95				
a_{1-2}							.814	.770				
a_{0-1}							.662	.651				
Naples (58):												
A_2	1.17	1.21	1.16	1.19	1.02	1.04	1.07	1.01	1.20	1.22	1.25	1.24
a_{2-4}	.878	.857	.815	.860	.826	.828	.830	.828	.855	.867	.864	.855
a_{0-1}	.678	.763	.729	.733	.657	.684	.692	.664	.754	.733	.750	.743
Montpellier (52):												
A_m	1.05	1.09	1.12	1.16	1.14	1.14	1.13	1.12	1.12	1.09	1.05	1.01
m	2.32	1.81	1.42	1.20	1.09	1.06	1.08	1.15	1.31	1.64	2.13	2.54
Paris (63):												
A_m	0.87	1.00	1.12	1.16	1.14	1.14	1.14	1.12	1.10	1.04	0.94	0.84
m	2.86	2.10	1.57	1.28	1.15	1.10	1.12	1.22	1.44	1.86	2.60	3.24
A_{max}	1.37	1.38	1.48	1.48	1.47	1.47	1.46	1.41	1.46	1.43	1.33	1.24
m	2.52	2.31	1.48	1.28	1.24	1.14	1.18	1.27	1.37	1.78	2.23	3.53
Mont Blanc (49):												
A_m									1.66			
m									1.39			
Jungfraujoch (32):												
A_2									1.56			
a_{2-3}									.931			
a_{0-1}									.877			
Davos (15):												
A_2	1.49	1.45	1.37	1.34	1.26	1.20	1.21	1.29	1.34	1.39	1.43	1.43
a_{2-3}	.901	.876	.861	.880	.889	.920	.937	.882	.881	.887	.874	.915
a_{0-1}	.825	.832	.818	.816	.795	.780	.749	.777	.794	.820	.822	.784
Gornergrat (26):												
A_2						1.30						
a_{2-3}						.855						
a_{0-1}						.856						
Agra (2):												
A_2	1.39	1.46	1.25	1.20	1.10	1.06	0.95	1.09	1.21	1.30	1.35	1.37
a_{2-3}	.892	.907	.857	.848	.825	.828	.818	.821	.847	.892	.880	.912
0-1	.779	.808	.747	.773	.734	.705	.653	.692	.743	.748	.776	.760
Arosa (6):												
A_2	1.52	1.52	1.47	1.43	1.35	1.33	1.34	1.36	1.41	1.45	1.48	1.54
a_{2-3}	.921	.921	.905	.895	.881	.880	.888	.904	.908	.917	.939	
a_{0-1}	.830	.837	.844	.827	.808	.805	.795	.809	.815	.810	.802	
Lausanne (41):												
A_m	0.79	0.85	0.90	0.91	0.86	0.85	.086	0.88	0.86	0.86	0.82	0.75
m	2.59	1.97	1.50	1.25	1.12	1.09	1.10	1.19	1.38	1.76	2.36	2.87

TABLE 7.—*Monthly means of solar radiation and atmospheric transmission*—Continued

Stations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Sonnblick (Alta Vista) (74):												
A_2						1.44						
a_{2-3}						.912						
a_{0-1}						.890						
Innsbruck (30):												
A_m	1.09	1.20	1.20	1.24	1.27	1.28						
m	2.69	2.02	1.52	1.26	1.13	1.09						
Algau (3):												
A_2	1.40	1.33	1.27	1.25	1.20	1.13	1.13	1.21	1.28	1.30	1.31	1.36
a_{2-3}	.900	.895	.866	.808	.825	.805	.858	.851	.855	.877	.878	.868
a_{0-1}	.775	.756	.767	.791	.771	.767	.736	.751	.795	.758	.752	.755
Frankfort on the Main (23):												
A_2	1.50	1.28	1.16	1.12	1.09	1.01	1.01	1.10	1.23	1.41	1.42	(1)
a_{2-3}	.893	.919	.826	.792	.782	.748	.748	.748	.783	.879	.920	(1)
a_{0-1}	.841	.707	.731	.737	.737	.722	.722	.779	.819	.829	.799	(1)
Kolberg (37):												
A_2			1.31	1.21	1.12	1.08	0.91	1.01	1.17	1.30		
a_{2-3}			.828	.795	.800	.816	.824	.848	.864	.791		
a_{0-1}			.783	.793	.768	.713	.699	.674	.668	.780		
A_m	0.88	1.20									0.99	0.82
m	3.85	2.57									3.36	4.54
Lindenberg (44):												
A_{max}	0.60	0.85	1.05	1.21	1.25	1.15	1.08	1.05	1.02	0.91	0.71	0.51
m	3.43	2.47	1.70	1.35	1.19	1.14	1.17	1.27	1.53	2.07	3.02	3.96
Potsdam (67):												
A_2	1.27	1.25	1.14	1.16	1.08	1.06	0.98	0.96	1.11	1.14	1.21	1.20
a_{2-3}	.874	.865	.859	.814	.767	.808	.801	.772	.818	.822	.904	.866
a_{0-1}	.728	.731	.681	.747	.742	.701	.658	.660	.709	.714	.670	.690
St. Blasien (69):												
A_2	1.37	1.31	1.26	1.11	1.06	1.06	1.06	1.13	1.13	1.24	1.22	1.32
a_{2-3}	.893	.886	.849	.810	.814	.794	.814	.835	.879	.828	.909	.896
a_{0-1}	.760	.731	.731	.754	.739	.714	.699	.719	.704	.764	.686	.740
Wahnsdorf (87):												
A_2					Mean for the year, 0.96							
a_{2-3}					Mean for the year, 0.688							
Feldberg (19):												
A_2	1.28	1.24	1.15	1.08	1.15	1.04	1.14	1.21	1.25	1.32	1.34	1.32
a_{2-3}	.859	.868	.862	.850	.839	.829	.871	.864	.881	.890	.902	.886
a_{0-1}	.740	.751	.690	.702	.718	.688	.720	.762	.746	.758	.752	.735
Karlsruhe (33):												
A_2	0.92	1.07	1.17	1.01	0.98	0.95	0.87	0.85	1.02	0.95	0.98	1.00
a_{2-3}	.891	.813	.863	.802	.779	.811	.775	.755	.775	.852	.838	.850
a_{0-1}		.665	.696	.666	.697	.672	.637	.598	.709	.584	.590	
Eskdaelmuir (17):												
A_m	0.92	1.06	1.16	1.16	1.25	1.23	1.28	1.21	1.21	1.16	0.95	0.85
m	4.14	2.70	1.83	1.43	1.24	1.18	1.20	1.33	1.63	2.29	3.55	4.98
Kew Observatory (35):												
A_m	0.70	0.77	0.99	1.01	1.04	1.08	1.02	1.06	0.98	0.87	0.75	0.67
m	3.28	2.31	1.60	1.33	1.18	1.13	1.15	1.26	1.50	2.02	2.90	3.77
Hald (27):												
A_m	0.72	0.88	0.87		1.08	1.10	1.32	1.33	1.20	1.22	0.80	0.92
m	4.48	2.82	1.89		1.26	1.19	1.22	1.36	1.67	2.39	3.80	5.46
Ursanova (86):												
A_2						1.01	1.06	1.08				
a_{2-3}						.786	.807	.807				
a_{0-1}						.687	.701	.713				
Warsaw (88):												
A_m	0.87	1.02	1.15	1.22	1.22	1.19	1.19	1.19	1.19	1.09	0.94	0.78
m	3.39	2.36	1.70	1.37	1.20	1.14	1.17	1.28	1.52	2.06	2.90	3.82
Zakopane (90):												
A_m								1.21	1.24			
m								1.24	1.44			
Mount Czarnohora (54):												
Worchta—												
A_2								1.30				
a_{1-3}								.929				
a_{0-1}								.739				
Jablonica—												
A_2								1.33				
a_{1-3}								.902				
a_{0-1}								.792				
Pożyżewska—												
A_2							1.26	1.26	1.22	1.29		
a_{1-3}							.841	.841	.820	.884		
a_{0-1}							.811	.789	.757	.770		
Chomiak—												
A_2								1.25				
a_{1-3}								.848				
a_{0-1}								.782				
Pożyżewska—												
A_2								1.42				
a_{1-3}								.930				
a_{0-1}								.810				
Howerla—												
A_2								1.50				
a_{1-3}								.920				
a_{0-1}								.852				

[1] December and January combined.

TABLE 7.—*Monthly means of solar radiation and atmospheric transmission*—Continued

Stations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Katharinenburg (34):												
A_m		1.27	1.40	1.41	1.37	1.26	1.26	1.33	1.27	1.26	1.24	
m		3.26	1.96	1.46	1.25	1.20	1.22	1.37	1.71	2.90	3.59	
$A_m = (2.45)$		1.41	1.33	1.25	1.13	1.03	0.99	1.11	1.17	1.31	1.40	
Kief (36):												
A_m			1.28		1.32	1.22		1.27	1.25	1.17	1.11	1.13
m			1.68		1.18	1.12		1.31	1.47	2.24	3.19	8.49
Leningrad (42):												
A_m	0.97	1.14	1.33	1.35	1.35	1.31	1.28	1.26	1.27	1.18	0.99	0.70
m	6.10	3.37	2.10	1.55	1.32	1.25	1.28	1.44	1.82	2.75	4.90	8.10
Moscow (53):												
A_m					1.31	1.27	1.30	1.28				
$a_{1\cdot2\cdot3\cdot4\cdot5}$						0.82	0.80	0.82				
m					1.20	1.18	1.21	1.34				
Nijni-Oltchedaeff (59):												
A_m	1.05	1.29	1.25	1.26	1.25	1.19	1.12	1.17	1.22	1.07	1.03	0.94
m	2.84	2.10	1.56	1.28	1.15	1.11	1.12	1.22	1.43	1.86	2.56	3.20
Pavlovsk (Sloutzk) (64):												
A_2			1.32	1.31		1.22	1.18	1.16	1.29			
a_{2-3}			.883	.853		.860	.855	.872	.864			
a_{0-1}			.749	.792		.749	.756	.751	.778			
A_m	0.87	1.10	1.23	1.29	1.32	1.33	1.29	1.23	1.18	1.13	0.96	0.81
m	5.95	3.34	2.08	1.54	1.31	1.24	1.27	1.44	1.82	2.72	4.80	7.80
Tashkent (75):												
A_m	1.38	1.43	1.39	1.39								
m	2.14	1.71	1.37	1.18								
Théodosie (81):												
A_m	1.16	1.22	1.24	1.14	1.20	1.23	1.22	1.23	1.22	1.17	1.14	
m	2.45	1.88	1.44	1.24	1.12	1.08	1.09	1.17	1.34	1.70	2.24	
Treurenberg (84):												
A_2				1.36	1.30	1.32	1.36		1.32			
a_{2-3}				.877	.879	.851	.894		.905			
Abisko (1):												
A_2							1.17	1.16	1.11			
a_{2-3}							.841	.840	.870			
a_{0-1}							.725	.727	.646			
Nyköping (61):												
A_2			1.29	1.29	1.20	1.26			1.24			
a_{2-3}			.862	.866	.899	.891			.898			
a_{0-1}			.766	.771	.772	.756			.756			
A_m	0.80	1.12					1.30	1.29		1.23	0.96	0.62
m	5.25	4.08					1.49	1.45		2.20	4.52	9.07
Upsala (85):												
A_2		1.29	1.30	1.28	1.21	1.17	1.19	1.20	1.24	1.31		
A_4	1.03										1.03	
a_{2-3}		.902	.889	.879	.875	.870	.873	.893	.876	.899		
a_{0-1}			.741	.770	.745	.743	.735	.715	.747			
Helwan (28):												
A_2	1.31	1.28	1.22	1.16	1.13	1.12	1.13	1.15	1.17	1.19	1.23	1.27
$a_{1\cdot4\cdot1\cdot3}$	.872	.864	.844	.826	.818	.811	.836	.834	.844	.848	.857	.861
a_{0-1}	.748	.742	.738	.730	.732	.738	.724	.728	.725	.719	.722	.737
Bassour (8):												
A_2								1.19	1.24	1.34	1.37	
a_{2-3}								.855	.846	.883	.902	
a_{0-1}								.752	.754	.778	.772	
Johannesburg (31):												
A_{max}	1.60	1.54	1.49	1.54	1.37	1.29	1.36	1.34	1.29	1.54	1.56	1.61
m	1.01	1.03	1.09	1.24	1.42	1.54	1.48	1.30	1.15	1.05	1.02	1.01
Simla (72):												
A_m	1.49	1.48	1.50	1.47	1.42	1.29	1.29	1.38	1.43	1.47	1.49	1.50
m	1.62	1.39	1.19	1.07	1.03	1.02	1.02	1.05	1.13	1.30	1.54	1.72
Batavia (9):												
A_2	1.13	1.13	1.03	1.13	0.98	0.99	0.93	0.86	0.89	0.79	1.05	1.08
a_{2-3}	.750	.857	.917	.737	.806	.825	.798	.790	.871	.881	.702	.727
a_{0-1}	.686	.665	.697	.711	.677	.686	.704	.643	.630	.600	.711	.714
Pangerango (62):												
A_2						1.41	1.50	1.45				
a_{2-3}						.860	.891	.890				
a_{0-1}						.874	.919	.876				
Smeroe (73):												
A_2				1.27				1.53				
a_{1-3}				.754				.887				
a_{0-1}				.904				.925				
Tjisoeroepan (82):												
A_2							1.30					
a_{2-3}							.861					
a_{0-1}							.801					
Bangkok (7):												
A_m					1.22							
m					1.01							
Fuji (25):												
A_2							1.49					
a_{2-3}							.926					
a_{0-1}							.862					
Numazu (60):												
A_2							1.12					
a_{2-3}							.877					
a_{0-1}							.792					

TABLE 7.—*Monthly means of solar radiation and atmospheric transmission*—Continued

OBESERVATIONS AT SEA

Stations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Atlantic Ocean (91):												
A_m			1.44									
m			1.38									
Mediterranean (92):												
A_m			1.42					1.35				
m			1.28					1.06				
Suez Canal (93):												
A_m			1.26									
m			1.15									
Red Sea (94):												
A_m			1.28				1.21	1.21				
m			1.09				1.00	1.00				
Gulf of Aden (95):												
A_m			1.41				1.16					
m			1.03				1.02					
Indian Ocean (96):												
A_m			1.41				1.24					
m			1.01				1.04					
Gulf of Siam (97):												
A_m				1.28								
m				1.01								

	Nov.-Feb.	Mar., Apr., Sept., Oct.	May-Aug.	Dec.
Oceania:				
Apia (4)—				
A_2	1.098	0.976	0.975	
a_{2-3}	.846	.848	.817	
a_{0-1}	.653	.617	.632	
Flint Island (21)—				
A_1				1.29
a_{0-1}				.664

MEASUREMENTS FROM BALLOONS

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Omaha (98):												
A_m							1.78					
m							1.06					
Griesheim (99):												
A_m										1.72		
m										2.04		

TABLE 8.—*Sources of pyrheliometric data*

ABISKO.

LINDHOLM, F. 1919. Sur l'insolation dans la Suède septentrionale. Kungl. Svenska Vetenskapsakad. Handlingar Bd. 60, No. 2., Stockholm.

FUNKE, A. 1921. Mesures de la radiation solaire à Abisko pendant l'été 1914. Meddelanden från Stat. Met. Hydrog. Anstalt. Bd. 1, No. 3. Nyköping.

AGRA.

SÜRING, R. 1924. Strahlungsklimatische Untersuchungen in Agra (Tessin). Met. Zeit. 41: 325. Braunschweig.

ALGÄU (RIEZLERN).

HOELPER, OTTO. 1924. Strahlungsmessungen in Algäu. Met. Zeit., 41: 346. Braunschweig.

APIA.

THOMSON, ANDREW. 1927. Ms. tables.

AREQUIPA.

ABBOT, C. G. 1916. Arequipa pyrheliometry. Smithsonian miscellaneous collections, v. 65, No. 9. Washington.

AROSA.

GÖTZ, F. W. PAUL. 1926. Das Strahlungsklima von Arosa. Berlin.

BANGKOK.

GORCZYŃSKI, LADISLAUS. 1923. Report from the Polish actinometric expedition to Siam and the equatorial region. Bulletin Météorologique, Institut Central Météorologique à Varsovie, pp. 90–92. Warsaw.

BASSOUR.

ABBOT, C. G. & OTHERS. 1913. Annals Astrophysical Observatory, Smithsonian Institution, III: 96–98. Washington.

BATAVIA.

SHAW, SIR NAPIER. 1926. Radiation in relation to meteorology. Union Géod. et Géoph. Int. Section de Météorologie. Procès-verbaux, Deuxième Assemblée Générale, Madrid, 1924, p. 114. Rome.

CALAMA.

ABBOT, C. G., & OTHERS. 1922. Annals Astrophysical Observatory, Smithsonian Institution, IV: 118–127. Washington.

Mount Montezuma.

ABBOT, C. G. 1926. Montezuma pyrheliometry. Mo. Wea. Rev., Supplement No. 27. Washington.

CAPE HORN.

International Polar Expedition, 1882–1883. (France.) 1885. Observations des radiations solaires. Mission scientifique du Cap Horn, 1882–1883. Tome 2. Météorologie. Seconde partie, s. 59–73. Paris.

CHEYENNE.

KIMBALL, HERBERT H. 1919. Variations in the total and luminous solar radiation with geographical position in the United States. Mo. Wea. Rev., 47: 776. Washington.

CORDOBA.

BIGELOW, F. H. 1914. Bulletins of the Argentine Meteorological Office, No. 4, pp. 137–140. Buenos Aires.

CORLETO.

CHISTONI, CIRO. 1903. Misure pireliometriche eseguite a Corleto nell' estate del 1898. Rend. Acc. Lincei, ser. 5, v. 12, 1 sem., p. 53–57. Rome.

DAVOS.

DORNO, C. 1919. Himmelshelligkeit, Himmelspolarisation, Sonnenintensität in Davos, 1911–1918. Veröff. des Preuss. Met. Inst., No. 303. Abh. Band VI. Table 60. Braunschweig.

ELLIJAY.

KIMBALL, HERBERT H. 1919. Variations in the total and luminous solar radiation with geographical position in the United States. Mo. Wea. Rev., Nov. 47: 775. Washington.

ESKDALEMUIR.

GREAT BRITAIN, METEOROLOGICAL OFFICE. 1909–10. Annual report, Observatory department, National Physical Laboratory. Report of Sup't Eskdalemuir Obs'y, Appendix II, Table 5. London.

GREAT BRITAIN, METEOROLOGICAL OFFICE. 1911–1922. British Met'l and Magnetic Year Book, Part III, section 2. The Geophysical Journal. London.

ETNA (MOUNT).

BELLIA, C. 1908. Risultati delle misure pireliometriche eseguite sull' Etna a 1,885 m. e 2,950 m. di altezza. Mem. Soc. spettr. ital., v. 37, p. 200–207, Catania.

FELDBERG.

PEPPLER, ALBERT & WILHELM. 1925. Beiträge zum Strahlungsklima Badens (1 Teil). Veröffentl. d. Bad. Landeswetterwarte Nr. 7. Karlsruhe.

FLAGSTAFF.

KIMBALL, HERBERT H. 1911. Some causes of variation in the polarization of skylight. Jr. Franklin Institute. 171: 333–344. Philadelphia. (See also Mo. Wea. Rev., Nov., 1919, 47: 776.)

FLINT ISLAND.

ABBOT, C. G. & OTHERS. 1913. Annals Astrophysical Observatory, III, 141–143. Washington.

FLORENCE.

ALFANI, P. GUIDO, D. S. P. 1917. Letture pireliometriche. Pub. dell' Osservatorio Ximeniano dei PP. Scalopi, Firenze, No. 123 and 125. Florence.

FRANKFORT ON THE MAIN.

LINKE, FRANZ. 1922. Normalwerte der Sonnenstrahlung am Taunus-Observatorium. Met. Zeit., 39: 392. Braunschweig.

FRESNO.

KIMBALL, HERBERT H. 1920. Solar radiation intensity in the Pacific Coast States. Mo. Wea. Rev., 48: 359. Washington.

FUJI AND NUMAZU.

OKADA, T. & YOSHIDA, Y. 1910. Pyrheliometric observations at the summit and at the base of Mount Fuji. Bull. Central Meteorological Observatory, Japan, No. 3. Tokio.

GORNERGRAT.

SCHEINER, J. 1908. Untersuchungen über die Solarkonstante und die Temperatur der Sonnenphotosphäre. Publikationen des Astrophysikalischen Observatoriums zu Potsdam. No. 55, 18. Band. 3d. Stück. Potsdam.

HALD.

HOLM, RAGNAR & JANSSON, MARTIN. 1904. Mesures actinométriques. In Travaux de la station Franco-Scandinave de sondages aériens à Hald 1902–1903. p. 30–38. Viborg.

HELWAN.
SHAW, KNOX. 1924. Ms. tables.
HUMP MOUNTAIN.
ABBOT, C. G. & OTHERS. 1922. Annals of the Astrophysical Observatory, Smithsonian Institution, IV: 116-117. Washington.
INNSBRUCK.
MYRBACH-RHEINFELD, DR. OTTO. 1910. Uber die Abhängigkeit des Transmissionskoeffizienten der Atmosphäre für die Sonnenstrahlung von Feuchtigkeit, Luftdruck und Wetterlage in Innsbruck. Sitz. ber. Ak. Wien. Mathem.-naturw. Klasse; 119:419-435. Vienna.
JOHANNESBURG.
Transvaal, Meteorological Dep't. 1907-10. Annual reports. Pretoria; Union Astronomer, July, 1910-June, 1911. Ms. tables.
JUNGFRAUJOCH.
STEIN, M. EDWARD. 1924. Mesures de la radiation solaire à Jungfraujoch. Comptes Rendus. 178:513, Paris.
KARLSRUHE.
PEPPLER, ALBERT & WILHELM. 1925. Beiträge zum Strahlungsklima Badens (1 Teil). Veröffentlichungen der Bad. Landeswetterwarte Nr. 7. Karlsruhe.
KATHARINENBURG.
MÜLLER, P. 1900. Aktinometer-Beobachtungen im Observatorium zu Katharinenburg. Bull. Acad. sci. St. Petersburg 1899, Tome XI, p. 61-78. St. Petersburg.
KEW OBSERVATORY.
GREAT BRITAIN, METEOROLOGICAL OFFICE, 1908-10. Ann. report, Observatory Dep't, Nat'l Physics Lab. Report of Sup't Kew Observatory, Appendix II, Table 4. London.
WATSON, R. E. 1923. Pyrheliometric comparisons at Kew Observatory. Meteorological Office. Geophysical Memoirs, No. 21. London.
KIEF.
SAVELIEF, M. R. 1889. Sur la marche de la radiation solaire à Kief pendant l'année 1888. Ann. Chim. Phys. 6. sér. Tome 18., p. 458-462. Paris.
KOLBERG.
KÄHLER, K. 1920. Strahlungs- und Helligkeitsmessungen in Kolberg. Veröff. Preuss. Meteorologischen Instituts. Abhandl. Band VII. Nr. 2., Table 15, p. 14. Berlin.
LA CONFIANZA.
BIGELOW, F. H. 1914. Bulletins of the Argentine Meteorological Office, No. 4, p. 129. Buenos Aires.
LA JOLLA.
KIMBALL, HERBERT H. 1920. Solar radiation intensity in the Pacific Coast States. Mo. Wea. Rev., 48:359. Washington.
LA QUIACA.
BIGELOW, F. H. 1914. Bulletins Argentine Meteorological Office, No. 4, p. 141-142, Buenos Aires.
LAUSANNE.
DUFOUR, HENRI. 1903. L'insolation en Suisse. 1 partie. Arch. sci. phys. nat. Genève. 4 pér. Tome 16, p. 417-434. Ibid. 2 partie, p. 526-540. Geneva.
BÜHRER, C. & DUFOUR, HENRI. 1905. Résumé des observations actinométriques de l'année 1903. Arch. sci. phys. nat. 4 pér. Tome 19, p. 388-390. Geneva.
LENINGRAD.
RYKATCHEW, M. 1896-1908. Central physical Nicholas Observatory. Annals, Part 1. 1895-1904. St. Petersburg.
LINCOLN.
KIMBALL, HERBERT H. 1916-1925. Solar radiation measurements at Lincoln, Nebr., 1911-1915. Mo. Wea. Rev. 44: 5. (Monthly thereafter under Solar and sky radiation measurements.) Washington.
LINDENBERG.
ROBITZSCH, M. 1920. Einige Ergebnisse von Strahlungsregistrierungen, die im Jahre 1919 in Lindenberg gewonnen wurden. Beiträge zur Physik der freien Atmosphäre, 9. Band, pp. 91-98. Leipzig.
MADISON.
KIMBALL, HERBERT H. 1912. Solar radiation intensities at Madison, Wis. Bulletin Mt. Weather Obs'y, 5:173-182. Washington.
KIMBALL, HERBERT H. & MILLER, ERIC R. 1916. Solar radiation measurements at Madison, Wis., 1913-1915. Mo. Wea. Rev. 44:8. (Monthly thereafter under Solar and sky radiation measurements.) Washington.
MADRID.
OBSERVATORIO ASTRONÓMICO DE MADRID. 1912-1925. Anuario. Madrid.
MEDFORD.
KIMBALL, HERBERT H. 1920. Solar radiation intensities in the Pacific Coast States. Mo. Wea. Rev., 48:359. Washington.
MODENA.
CHISTONI, CIRO. 1905. Risultati pireliometrici ottenuti coll' attinometro di Violle negli anni 1900 e 1901 al R. Osservatorio geofisico di Modena. Rend. Acc. Lincei. Ser. 5, v. 14, 1 sem., p. 147-153. Rome.
CHISTONI, CIRO. 1905. Risultati pireliometrici ottenuti dall' ottobre 1901 al 3 luglio 1902 al R. Osservatorio geofisico di Modena. Rend. Acc. Lincei. Ser. 5, v. 14, 1 sem., 560-567. Rome.
3 luglio al 21 agosto 1902. Ibid. 2 sem., p. 76-82. Rome.
1906. 22 agosto a tutto giugno 1903. Ibid. v. 15, 1 sem., p. 126-132. Rome.
MONT BLANC.
HANSKY, A. 1905. Observations actinométriques faites au sommet du Mont Blanc. Comptes rendus. Tome 140, pp. 422-425. Paris.
Ibid., pp. 1008-1010.
MONTE CIMONE.
CHISTONI, CIRO. 1903. Misure pireliometriche eseguite a Sestola ed al Monte Cimone nell' estate 1899. Rend. Acc. Lincei, ser. 5, v. 12, 1 sem., p. 258-263. Rome.
Ibid. (estate 1900), v. 12. 2d. sem., pp. 625-628.
CHISTONI, CIRO. 1902. Misure pireliometriche fatte sul Monte Cimone nell'estate del 1901. Rend. Acc. Lincei, ser. 5, v. 11, 1 sem., pp. 539-541. Rome.
Ibid. 1906. Estate 1902 e 1903, Rend. Acc. Lincei. ser. 5. v. 15, 1 sem., pp. 208-213. Rome.
(Estate 1904 e 1905), Ibid. pp. 276-281.
MONTE ROSA.
ALESSANDRI, C. 1908. La radiazione solare al Monte Rosa. Mem. Soc. spettr. Ital. Catania, v. 37, p. 127-141. Catania.
ALESSANDRI, C. 1908. La radiazione solare al Monte Rosa. Osservazioni eseguite alla Capanna-Osservatorio Regina Margherita negli anni 1905-1906; Rend. Acc. Lincei, ser. 5, v. 17, 2 sem., pp. 58-65. Rome.
Ibid. 1908 (anni 1907), p. 214-225.
ALESSANDRI, C. 1908. La radiazione attinica del sole al Monte Rosa. Osservazioni eseguite alla Capanna-Osservatorio Regina Margherita coll'attinometro fotoelettrico di Elster e Geitel. Rend. Acc. Lincei, ser. 5, vol. 17, 2 sem., pp. 113-118. Rome.
MONTPELLIER.
EON, L. J. 1901. Intensités calorifiques de la radiation solaire et durée de l'insolation à Montpellier. Année 1900 et résumé de la série 1883-1900. Bulletin météorologique du Département de l'Hérault, année 1900. Montpellier.
MOSCOW.
BONTCHKOVSKY. 1923. Observations actinométriques. Bulletin de l'Institut de physique cosmique de Moscou. Fascicule 1, pp. 107-110. Moscow.
MOUNT CZARNOHORA.
STENZ, E. 1924. Observations pyrhéliométriques anciennes faites dans les monts de Czarnohora. Institut de géophysique et de météorologie de l'Université de Lwów, v. 46-50, Nos. 12 and 14, pp. 480-489. Lwów.
STENZ, E. & ORKISZ, H. 1925. Observations pyrhéliométriques faites dans les Carpathes orientales durant l'été de l'année 1924. Institut de géophysique et de météorologie de l'Université de Lwów, pp. 421-461. Lwów.
MOUNT WEATHER.
KIMBALL, HERBERT H. 1912. Solar radiation intensities at Mt. Weather, Va. Bull. Mt. Weather Obs'y. Vol. 5, pp. 303-311. Washington.
Ibid. 1913. Vol. 6, pp. 205-206.
KIMBALL, HERBERT H. 1914. Mo. Wea. Rev. 42: pp. 138, 310, 520. Washington.
MOUNT WHITNEY.
ABBOT, C. G. & OTHERS. 1913. Annals of the Astrophysical Observatory, Smithsonian Institution, Vol. III, p. 99. Washington.
MOUNT WILSON.
ABBOT, C. G. & OTHERS. 1908. Annals of the Astrophysical Observatory, Smithsonian Institution, Vol. II, p. 73-95. Washington.
Ibid. 1913. Vol. III, pp. 73-95.
Ibid. 1922. Vol. IV, pp. 101-116.
MOUNT MONTEZUMA, see CALAMA.
NAPLES.
BEMPORAD, A. 1921. Osservazioni Pireliometriche eseguite a Capodimonte nell'anno 1914. Memorie del R. Osservatorio di Capodimonte. Naples.
NIJNI-OLTCHEDAEFF.
MORKOFF, COMTE IRACLY. 1912-1914. Observations mensuelles. Observatoire de météorologique et d'études des hautes régions de l'atmosphère à Nijni-Oltchedaeff. Kief.
NUMAZU, see FUJI.

NYKÖPING.
WESTMAN, J. 1920. Starke der Sonnenstrahlung im Mittelschwedischen Ostseegebiet. März 1918–Mai 1919. Meddelander Från Statens Meteorologisk-Hydrografiska Anstalt. Band 1, No. 1. Stockholm.
PANGERANGO.
SHAW, SIR NAPIER. 1926. Radiation in relation to meteorology. Procès-verbaux des Séances de la Section de météorologie. Union Géodésique et Géophysique Internationale. Deuxième Assemblée Générale. Madrid. October, 1924, p. 115. Rome.
GORCZYŃSKI, LADISLAUS. 1923. Preliminary report on the results obtained during a voyage in the equatorial region, March to August, 1923. Mo. Wea. Rev. Oct. 1923, vol. 51, p. 528–529. Washington.
PARIS.
BUREAU CENTRAL MÉTÉOROLOGIQUE DE FRANCE. 1907–14. Observations actinométriques faites au Parc Saint-Maur, Annales 1. Mémoires, 1907–1914. Paris.
INSTITUT DE PHYSIQUE DU GLOBE DE L'UNIVERSITÉ DE PARIS ET DU BUREAU CENTRAL DE MAGNÉTISME TERRESTRE. 1925. Annales, Tome III, pp. 126–137. Paris.
PAVLOVSK (SLOUTZK).
SAVINOV, S. I. 1913. The maxima of solar radiation at Pavlovsk since 1892. Bull. Ac. Imp. des Sci. St. Petersbourg, 6me. sér., No. 12, pp. 707–720. St. Petersbourg.
KALITIN, N. N. 1923. Die Wärmesummen der Sonnenstrahlung für Pawlowsk. Met., Zeit., vol. 40, p. 353. Braunschweig.
CENTRAL PHYSICAL NICHOLAS OBSERVATORY., Annals, Part 1, 1893, to date. St. Petersbourg.
SCHUKEWITSCH, J. 1894. Actinometrische Beobactungen im Konstantinowschen Observatorium zu Pavlovsk. Repert f. Meteorol. Bd. 17, No. 5. St. Petersbourg.
RUSSIA. OBSERVATOIRE GÉOPHYSIQUE CENTRAL, 1926. Bulletin de la Commission actinométrique permanente de l'Observatoire géophysique central. No. 1–2, 1925, No. 1, 1926. Leningrad.
PHOENIX.
KIMBALL, HERBERT H. 1911. Some causes of the variation in the polarization of skylight. Jr. Franklin Institute, 171:333–344. Philadelphia.
See also Mo. Wea. Rev., Nov. 1919, 47:776. Washington.
POMONA.
KIMBALL, HERBERT H. 1920. Solar radiation intensity in the Pacific Coast States. Mo. Wea. Rev., 48:359. Washington.
POTSDAM.
MARTEN, W. 1920. Normalwerte der Somenstrahlung in Potsdam. Met. Zeit., 37: 254, Table 2. Braunschweig.
RED BLUFF.
KIMBALL, HERBERT H. 1920. Solar radiation intensity in the Pacific Coast States. Mo. Wea. Rev., 48:359. Washington.
ST. BLASIEN.
BAUR, DR. FRANZ. 1922. Mitteilungen der Wetter und Sonnenwarte St. Blasien, Heft 1, Table 3, p. 14. St. Blasien.
PEPPLER, ALBERT & WILHELM. 1925. Beiträge zum Strahlungsklima Badens (1 Teil). Veröffentlichungen der Badischen Landeswetterwarte. Nr. 7. Karlsruhe.
SANTA FE.
KIMBALL, HERBERT H. 1915. Solar radiation measurements at Santa Fe, N. Mex., etc. Mo. Wea. Review, 43:439–443, 590, 44:2–4. Monthly thereafter. Washington.
Twin Mountain.
KIMBALL, HERBERT H. 1913. Observations on the increase of insolation with elevation. Bull. Mt. Weather Obs'y, VI, 107–110. Washington. Also Ms. tables.
Lake Peak.
Ibid.
SESTOLA.
CHISTONI, CIRO. 1913. Misure pireliometriche eseguite a Sestola ed al Monte Cimone nell'estate 1899. Rend. Acc. Lincei, Roma, ser. 5, v. XII, 1° sem., pp. 258–263. Rome.
Ibid (estate 1900) 2°. sem., 625–628.
CHISTONI, CIRO. 1902. Misure pireliometriche fatte a Sestola nell 'estate del 1901, ser. 5, V. XI, 1° sem., pp. 77–84. Rome.
SIMLA.
INDIA METEOROLOGICAL DEPARTMENT. 1908–15. India Weather Review, 1906–07. Simla.
Ibid. 1908–1913. Calcutta. Monthly Weather Review, 1914–15. Calcutta.
SMEROE.
SHAW, SIR NAPIER. 1926. Radiation in relation to meteorology. Procès-verbaux des Séances de la Section de météorologie. Union Géodésique et Géophysique Internationale. Deuxième Assemblée Générale. Madrid, Octobre, 1924, p. 115. Rome.
SONNBLICK.
EXNER, DR. F. 1903. Messungen der Sonnenstrahlung und der nächtlichen Ausstrahlung auf dem Sonnblick. Met. Zeit., 20:409. Braunschweig.
TASHKENT.
RUSSIA. OBSERVATOIRE GÉOPHYSIQUE CENTRAL. 1926. Bulletin de la Commission actinométrique permanente de l'Observatoire géophysique central. No. 1–2, 1925, No. 1, 1926. Leningrad.
TENERIFFE.
Pic de Teyde.
ÅNGSTRÖM, KNUT. 1900. Intensité de la radiation solaire à différentes altitudes. Recherches faites à Ténériffe 1895 et 1896, pp. 37–40. Upsala.
Alta Vista.
ÅNGSTRÖM, KNUT. 1900. Intensité de la radiation solaire à différentes altitudes. Recherches faites à Ténériffe 1895 et 1896, pp. 37–40. Upsala.
Izana.
SPAIN. OBSERVATORIO CENTRAL METEOROLÓGICO. 1917. Anuario. Suplemento al Tomo III, p. 132–136. Madrid.
Cañadas.
SPAIN. OBSERVATORIO CENTRAL METEOROLÓGICO. 1917. Anuario. Suplemento al Tomo II, p. 137–179. Madrid.
Guimar.
ÅNGSTRÖM, KNUT. 1900. Intensité de la radiation solaire à différentes altitudes. Recherches faites à Ténériffe 1895 et 1896, pp. 37–40. Upsala.
THEODOSIA.
RUSSIA. OBSERVATOIRE GÉOPHYSIQUE CENTRAL. 1925, 1926. Bulletin de la Commission actinométrique permanente de l'Observatoire géophysique central. No. 1–2, 1925, No. 1, 1926. Leningrad.
TJISOEROEPAN.
SHAW, SIR NAPIER. 1926. Radiation in relation to meteorology. Procès-verbaux des Séances de la Section de Météorologie. Union Géodésique et Géophysique Internationale. Deuxième Assemblée Générale. Madrid, October, 1924, p. 115. Rome.
TRAPP.
KIMBALL, HERBERT H. 1913. Observations on the increase of insolation with elevation. Bulletin Mt. Weather Obs'y, vol. 6, p. 107–110. Washington.
TREURENBERG.
WESTMAN, J. 1904. Mesures de l'intensité de la radiation solaire faites en 1899 et en 1900 à la station d'hivernage suédoise à la baie de Treurenberg, Spitzberg. Mission scientifique pour la mesure d'un arc de méridien au Spitzberg enterprises en 1899–1902 sous les auspices des gouvernments Suédois et Russe. Mission suédois. Tome 2. Section VIII. B. Stockholm.
UPSALA.
WESTMAN, J. 1907. Mesures de l'intensité de la radiation solaire. Kungl. Svenska vetenskapsakademiens handlingar, Bd. 42, No. 4. Upsala.
URSANOVA.
GORCZYŃSKI, LADISLAUS. 1910. Sur la valeur de la "constante solaire" d'après les mesures prises à Ursanova (Pologne) en été 1909. Extrait des comptes rendus des séances de la société scientifique de Varsovie; classe des sciences mathématiques et naturelles; III année (1910), fascicule 3 (Mars). Warswa.
WAHNSDORF.
JAHRBUCH DER SÄCHSISCHEN LANDES-WETTERWARTE. 1919. Beobachtungen im Jahre 1918 in Wahnsdorf auf dem Fichtelberg. I. und II. Abteilung des Jahrganges XXXVI (1918), Table 14, page 50. Dresden.
WARSAW.
GORCZYŃSKI, LADISLAUS. 1914. Valeurs pyrhéliométriques et les sommes d'insolation à Varsovie pendant la période 1901–1913. Publications de la Société scientifique de Varsovie. Commission Météorologique, Tome II. Warsaw.
STENZ, EDWARD. 1922. Intensité de la radiation solaire et l'insolation à Varsovie pendant la période 1913–1918. Annuaire de l'Institut Central Météorologique de Pologne, Année 1919, pp. 14–38. Warsaw.

WASHINGTON.

KIMBALL, HERBERT H. 1910. Solar radiation intensity at Washington, D. C. Bull. Mt. Weather Obs'y. Vol. III, Part 2, pp. 69–126. Washington.

KIMBALL, HERBERT H. 1915–1925. Mo. Wea. Rev. 42:648. 43:112. Monthly thereafter. Washington.

ZAKOPANE.

GORCZYŃSKI, LADISLAUS. 1906. Sur la march annuelle de l'intensité du rayonnement solaire à Varsovie et sur la théorie des appareils employés. page 127. Warsaw. (Authority given by Gorczyński; Witkowski, A. 1905. Spostrzezenia pyrheliometryczne w Zakopanem w lecie r. 1903. Spraw. Kom. Fizyogr., Kraków, 1905.)

MISCELLANEOUS.

Observations at sea.

GORCZYŃSKI, LADISLAUS. 1923. Report from the Polish Actinometric Expedition to Siam and the Equatorial Region. Bulletin Météorologique, Institut Central Météorologique à Varsovie. Septembre to October, 1923. pp. 90–92. Warsaw.

Observations from balloons:

OMAHA.

ABBOT, C. G. & OTHERS. 1922. Annals Astrophysical Observatory. Smithsonian Institution. Vol. IV, pp. 347–366. Washington.

GRIESHEIM AM MAIN.

PEPPLER, ALBERT & STUCHTEY, KARL. 1914. Absolute Messungen der Sonnenstrahlung auf Hochfahrten in den Aeronautischen Observatoriums. 1913. IX Band, pp. 349–364 Braunschweig.

Table 8 gives the sources of the data summarized in Table 7.

It will be noted that in Tables 6 and 7 each station is given a number, and that in Tables 6 and 8 the arrangement is alphabetical. In Table 7 the arrangement is geographical, beginning with South America, and then passing in succession to North American, the Canary Islands, southern, central, and northern Europe, Africa, India, Java, Siam, Japan, observations at sea, Oceania, and observations from balloons.

ATMOSPHERIC TRANSMISSION

The data of Table 7 have been summarized in convenient form for studying atmospheric transmission of solar radiation, or its complement, atmospheric depletion. The latter is due to four principal causes, as follows:

(1) Scattering by the gas molecules of dry pure air.

(2) Scattering by the water vapor in the atmosphere.

(3) Absorption by the gases of the atmosphere, principally by water vapor.

(4) Scattering and absorption by the dust particles suspended in the atmosphere.

Fowle (7) has shown that on high mountains above the dust of the lower levels atmospheric transmission by dry air, $a_{a\lambda}$, agrees closely with the theoretical equation developed by King (8) from Rayleigh's classical equations (9) as follows:

$a_{a\lambda} = e^{-k}$, where k

$$= \frac{32}{3}\left[\pi^3(n-1)^2 \frac{H}{N_0\lambda^4} + bH\right]\frac{P}{P_0} + D \qquad (1)$$

n = index of refraction of air.

$$(n-1)10^7 = 2875.16 + 13.412/\lambda^2 10^{-8} + 0.3777/\lambda^4 10^{-16}$$

H = height of the homogeneous atmosphere, = 799,000 cm.

P = observed pressure in cm. of mercury.

λ = wave length of light in cm.

N_0 = molecules per cm.^{3} (P_0 = 76.0 cm., t = 0°C.) $= 2.705 \times 10^{19}$

b = energy absorbed by the permanent gases and converted into heat.

D = depletion from atmospheric dust and haze, which probably does not vary greatly with λ, and becomes almost negligible at high altitudes.

Assuming b and D each equal to 0.0 and $P = P_0$, $a_{a\lambda}$ has been computed by equation (1) for 39 values of λ between 0.3415 μ and 2.442 μ, corresponding to prismatic deviations of the Smithsonian u. v. glass prism between +240′ and −40′, at intervals of 10′, except that between +120′ and +20′ the interval is 5′. The relative intensities of radiation for these wave lengths before depletion by the atmosphere, $e_{0\lambda}$, have been taken from Fowle's values (10) with interpolation where necessary. Let m = the air mass, approximately the secant of the sun's zenith distance, and a' the transmission coefficient for the total solar radiation through dry pure air. Then

$$e_{m\lambda} = e_{0\lambda} a^m{}_{a\lambda}, \text{ and} \qquad (2)$$

$$(a')^m = \frac{\Sigma e_{0\lambda} a^m{}_{a\lambda}}{\Sigma e_{0\lambda}} \qquad (3)$$

Both the numerator and the denominator of (3) must include corrections for both ultra-violet and infre-red radiation (11) beyond the limits of the wave-lengths considered.[3] The magnitude of these corrections appears to be known only approximately.

To take account of the scattering of solar radiation by atmospheric moisture, I have also used Fowle's (10) values of $a_{w\lambda}$. The equation for a' then becomes

$$(a')^m = \frac{\Sigma e_{0\lambda} (a_{a\lambda} a^w{}_{w\lambda})^m}{\Sigma e_{0\lambda}} \qquad (4)$$

where w is the depth of water in centimeters that would be obtained if all the moisture in the atmosphere were precipitated. If $w = 0$, equation (4) is identical with (3).

At stations of the Astrophysical Observatory of the Smithsonian Institution the value of w is determined spectrobolometrically. At other stations it is necessary to use Hann's equation, $w = 2.3\ e\ 10^{\frac{-h}{22000}}$ where e is the surface vapor pressure in centimeters, and h is altitude in meters above sea level. Fowle states (12) that this equation can be relied upon only when the mean values of e for a considerable period are used.

In Figure 3, the values computed from (3) for values of m = 1, 2, 3, 4, and 40.0/76.0 = 0.526, have been plotted as ordinates on the scale of their logarithms to the base 10. The abscissas have been numbered for an air pressure of 76 cm. Evidently, however, if $P < P_0$, unit air mass will fall on the abscissa corresponding to the value of P/P_0. Thus, if P = 40.0 cm., unit air mass falls at 0.526, 2 m. at 1.052, etc.

Similarly, the values computed from (4) for m = 1.0 2.0, 3.0, and 4.0, and values of w = 0.5, 1.0, 2.0, 3.0, and 4.0 cm., give curves 2–6, Figure 3. Values have also been computed for m = 0.526, but the form of the equation shows that for this value of m the precipitable water, w, represented by the curves is $\frac{P}{P_0} w$, where w is its value for

[3] As this paper goes to the printer I have received a copy of "Smithsonian Solar Radiation Researches," by C. G. Abbot (Sonderdruck aus "Gerlands Beitrage zur Geophysik," Bd. XVI, Heft 4, pp. 344–353, Leipsic, 1927). In it are given new determinations for these corrections that are much larger than those heretofore published. Their use would probably lead to lower transmission coefficients than are indicated by the curves of Figure 3.

$P=P_0$. Thus, for $P=40$ cm., on curves 2–6, $w=0.263$, 0.526, 1.052, 1.578, and 2.104, respectively.

From computed values of $(e_{0\lambda}a_{a\lambda}a^{w}_{w\lambda})^m$, $(a')^m$, and curves given by Fowle (10), I have determined the proportion of incoming radiation absorbed by quantities of water vapor represented by *wm,* where *w* has the same value as in curves 2–6. These computed values of water vapor absorption have been plotted on curve 12, Figure 3; and after increasing them by 0.5 at all air masses to take account of absorption by the permanent gases of the atmosphere (13) have been deducted from the value of $(a')^m$ to give values of $(a'')^m$ as plotted on Figure 3 in

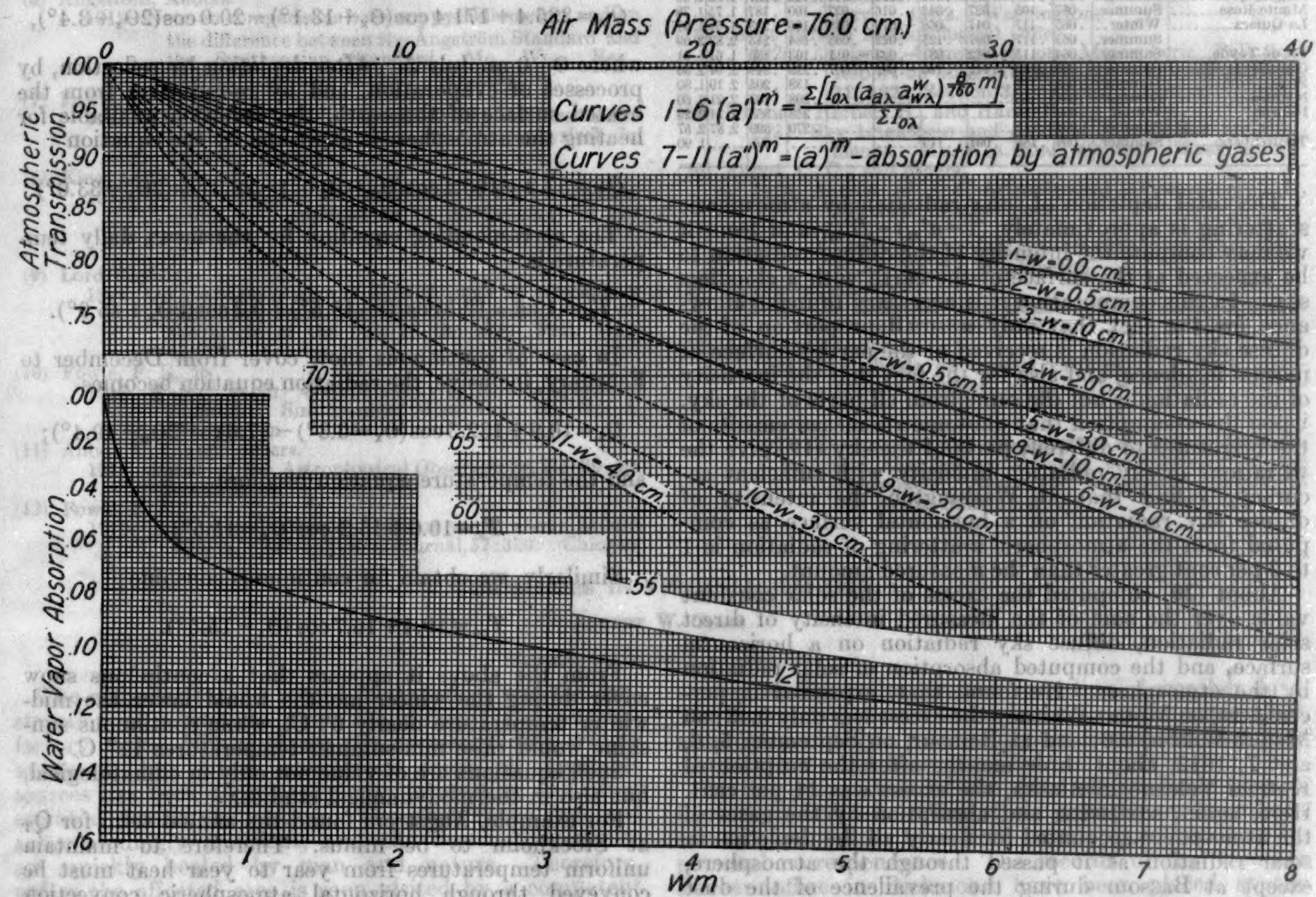

FIG. 3.—Atmospheric transmission of solar radiation through pure moist air

curves 7–11. They give the proportion of solar radiation that is transmitted by pure air containing the amounts of water vapor indicated.

The curves of Figure 3 do not take into account the depletion of solar radiation by the haze and dust in the atmosphere represented by the term D in equation (1). Undoubtedly this depletion results from both scattering and absorption; but since we do not know the relative amounts scattered and absorbed, the total is usually attributed to scattering and is here designated D'_m.

From the data in Table 7 and with the aid of Figure 3 we may determine with considerable accuracy the amount of depletion of solar radiation by the scattering and absorption of dry air, aqueous vapor, and haze and dust of the atmosphere. This has been done for a few typical stations, and the results are given in Table 9. Columns 3 and 4 give the scattering and absorption, E_m, by pure dry air; columns 5 and 6, the scattering and absorption, E_w, by water vapor; columns 9 and 10, the total depletion, $1-a_m$, as determined from the data in Table 7; columns 7 and 8, the depletion designated D'_m above, which is the difference between the total depletion of columns 9 and 10 and the sums of the depletions given in columns 3 and 5, and 4 and 6, respectively. The subscript figures affixed to E, E_w, D', and a in the heading of Table 9, indicate the values of m between which depletions were computed.

Linke (14) calls the ration $T_m=\frac{1-a_m}{E_m}$ the *atmospheric turbidity factor*, and Götz (15) and Milch (16) have made extensive use of this factor in recent publications. I have given values of T_{0-1} and T_{0-2} in the last two columns of Table 9.

An inspection of Table 9 shows but little depletion from water vapor or from dust on high mountains, which is in accord with the results obtained by Fowle (17). There is also less depletion from dust and haze on island stations than on continents. At Samoa it is less during the wet summer months than during the dry winter months. It has been shown (18) that haze at sea consists principally of minute salt crystals.

TABLE 9.—*Atmospheric depletion of solar radiation*

Station	Season	Dry air		Water vapor		Dust		Total		Turbidity factor	
		E_{e-1}	E_{e-2}	E_{we-1}	E_{we-2}	D'_{e-1}	D'_{e-2}	$1-a_{e-1}$	$1-a_{e-2}$	T_{e-1}	T_{e-2}
Apia	Winter	0.094	0.155	0.197	0.277	0.077	0.062	0.368	0.494	3.91	3.19
	Summer	.094	.155	.205	.287	.048	.005	.347	.447	3.69	2.88
Washington	Winter	.094	.155	.081	.101	.087	.141	.262	.397	2.79	2.56
	Summer	.094	.155	.165	.230	.103	.127	.362	.512	3.85	3.30
Mount Wilson	Summer	.079	.135	.106	.127	.021	.026	.206	.288	2.61	2.13
Mount Montezuma.	Winter	.070	.125	.048	.071	.021	.021	.139	.217	1.99	1.74
	Summer	.070	.125	.092	.127	.020	.016	.182	.268	2.00	2.14
Mount Whitney	Summer	.059	.106	.022	.040	.026	.034	.107	.180	1.81	1.70
Jungfraujoch	Summer	.066	.118	.037	.058	.020	.011	.123	.187	1.86	1.58
Monte Rosa	Summer	.057	.105	.027	.045	.016	.037	.100	.187	1.75	1.78
La Quiaca	Winter	.065	.117	.047	.068	−.012	.088	.100	.223	1.54	1.91
	Summer	.065	.117	.097	.125	.022	.003	.184	.245	2.83	2.09
Pic de Teyde	Summer	.064	.115	.062	.081	−.023	−.011	.103	.185	1.61	1.61
Guimar	Summer	.090	.152	.141	.100	−.002	.007	.229	.349	2.54	2.30
Fuji	Summer	.063	.114					.138	.205	2.19	1.80
Numazu	Summer	.094	.155					.208	.403	2.21	2.60
Helwan	Winter	.094	.155					.258	.355	2.74	2.29
	Summer	.094	.155					.270	.399	2.87	2.57
Treurenberg	Summer	.094	.155	.091	.119		.021		.295		1.90

The total depletion of solar radiation by atmospheric scattering is approximately $(1-a'_m)+D'_m$, and from it we may compute the intensity of the diffuse radiation to be expected at the surface of the earth with a cloudless sky. In this computation it is necessary to make allowance for the fact that only a small proportion of the diffuse sky radiation is received at the earth's surface at normal incidence, and also for the fact that the intensity of the radiation is not the same from all parts of the sky. Upon the assumption that photometric measurements of the brightness of different parts of the sky (**19**) give the variations in sky radiation intensity with sufficient accuracy, I find that at Washington the intensity of diffuse sky radiation on a horizontal surface as computed from the atmospheric scattering of radiation is 1 to 2 per cent greater than the measured amount.

Abbot (**20**) computed the excess of the solar constant value over the sum of the measured intensity of direct solar radiation, diffuse sky radiation on a horizontal surface, and the computed absorption of solar radiation by the atmosphere. He found that, expressed in percentages, on Mount Whitney the excess was only 0.43; on Mount Wilson, 2.0; and at Bassour, on September 5, 6, and 7, 1912, about three months after the eruption of Katmai Volcano in Alaska, the excess was 14 per cent. Here, again, scattering and absorption by the gases of the atmosphere accounted for nearly all the depletion in solar radiation as it passed through the atmosphere, except at Bassour during the prevailence of the dust cloud from Katmai Volcano.

Abbot (**21**) has shown that pyrheliometric measurements made on high mountains where there is little dust will show the nature of variations in the value of the solar constant. Therefore, the value to meteorologists of careful measurements of solar radiation intensity is apparent. It must be emphasized, however, that instrumental readings should be given in units of some known pyrheliometric scale, such as the Ångstrom scale, or the Smithsonian pyrheliometric scale of 1913. The relation between these two scales appears to be well known (**6**), so that radiation intensities expressed in one are readily reduced to the other.

THE RELATION BETWEEN SOLAR RADIATION AND AIR TEMPERATURE

Ångström (**22**) has shown the relation that exists between radiation and temperature. Briefly, the diurnal march of both radiation and temperature may be expressed by a Fourier series, the first constant of which gives the annual mean, and the constant of the first harmonic the annual amplitude.

For Washington, the equation for the mean daily radiation receipt on a horizontal surface from the sun and sky is

$$Q_m = 335.4 + 171.4\cos(\Theta_x + 13.1°) - 20.0\cos(2\Theta_x + 3.4°),$$

where $\Theta = 0$ on July 5. After depletion by reflection, by processes of evaporation, and by re-radiation from the heated surface of the earth, the radiation available for heating the atmosphere is expressed by the equation

$$Q_T = 32.2 + 106.4\cos(\Theta_x + 10.0°) - 22.3\cos(2\Theta_x - 33.0°)$$

The corresponding equation for the mean daily temperature is

$$T_m = 12.8 + 12.3\cos(\Theta - 15.5°) + 0.3\cos(2\Theta_x + 45.9°).$$

In case of continuous snow cover from December to February, inclusive, the radiation equation becomes

$$Q_s = 10.9 + 132.3\cos(\Theta_x - 0.3°) - 37.6\cos(2\Theta_x - 49.4°);$$

and the temperature equation becomes

$$T_s = 10.0 + 15.3\cos(\Theta_x - 15.5°).$$

Similarly, we obtain for continuous sunshine

$$T_{co} = 19.4 + 16.7\cos(\Theta_x - 15.5°).$$

From the above it appears that a continuous snow cover during the winter months would lower the midwinter temperature nearly 6° C., while continuous sunshine would raise min-summer temperatures 11° C.

Such equations are of value not only in climatological, but also in thermodynamical studies.

For example, Ångström found the annual term for Q_T at Stockholm to be minus. Therefore to maintain uniform temperatures from year to year heat must be conveyed through horizontal atmospheric convection from low latitudes to high latitudes.

It becomes apparent that several factors besides the incoming radiation require careful measurement, such as the albedo of the surface of the earth, the rate of evaporation from the surface of the earth, and the intensity of the outgoing radiation at all seasons of the year and hours of the day. Ångström (**23**), (**24**) is now making valuable contributions along these lines.

LITERATURE CITED

(1) Ångström, Anders.
1924. Solar and Terrestrial Radiation. Qr. Jr. R. Meteorological Soc. 50:121–126. London.

(2) Kimball, Herbert H.
1919. Variations in the total and luminous solar radiation with geographical position in the United States. Mo. Wea. Rev., 47:769–793. See especially Figure 9, p. 780. Washington.
(3) Kimball, Herbert H., and Hand, Irving F.
1922. Daylight illumination on horizontal, vertical, and sloping surfaces. Mo. Wea. Rev., 50:615–628. Washington.
(4) Kimball, Herbert H.
1925. Daylight illumination on sloping surfaces. A correction. Mo. Wea. Rev., 53:448. Washington.
(5) Abbot, C. G., and others.
1913. Annals of the Astrophysical Observatory, Smithsonian Institution, III, 69. Washington.
(6) Ångström, Anders.
1919. Note on comparisons between pyrheliometers and on the difference between the Ångström Standard and the Smithsonian Standard. Mo. Wea. Rev., 47:798. See also 48:147. Washington.
(7) Fowle, F. E., jr.
1913. The nonselective transmissibility of radiation through dry and moist air. Astrophysical Jr. 38:392. Chicago.
(8) King, Louis Vessot.
1913. On the scattering and absorption of light in gaseous media with applications to the intensity of sky radiation. Phil. Trans. R. Soc. London, A. 212, 375. London.
(9) Lord Rayleigh.
1899. On the transmission of light through an atmosphere containing small particles in suspension, and on the origin of the blue of the sky. Phil. Mag. 47:375. London.
(10) Fowle, F. E., jr.
1917. Water vapor transparency to low-temperature radiation. Smithsonian Misc. Coll. 68, No. 8. Washington.
(11) Abbot, C. G., and others.
1913. Annals of the Astrophysical Observatory, III:39–40. Washington.
(12) Fowle, F. E., jr.
1913. The determination of aqueous vapor above Mount Wilson. Astrophysical Journal, 37:359. Chicgao.
(13) Fowle, F. E., jr.
1915. The transparency of aqueous vapor. Astrophysical Journal, 42: 394. Chicago.
(14) Linke, F.
1922. Transmissionskoeffizient und Trubungsfactor. Beitr. Z. Phys. d. frëien Atmosphäre. 10: 91. Leipzig.
(15) Götz, F. W. Paul.
1926. Das Strahlungsklima von Arosa. Berlin.
(16) Milch, W.
1927. Über die Extinktion der langwelligen und der kurgwelligen Sonnenstrahlung in der Atmosphäre der Erde. Gerlands Beiträge z. Geophysik, 16: 66. Leipzig.
(17) Fowle, F. E., jr.
1914. Atmospheric transparency to radiation. Mo. Wea. Rev. 42: 2. Washington.
(18) Great Britain Meteorological Office.
1926. Advisory Committee on Atmospheric Pollution. Report on observations in the year ending March 31, 1925, Section 3, p. 42–44. London.
(19) Kimball, Herbert H., and Hand, Irving F.
1921. Sky brightness and daylight-illumination measurements. Mo. Wea. Rev., 49: 481. Washington.
(20) Abbot, C. G., and others.
1913. Annals of the Astrophysical Observatory, III, 150–151. Washington.
(21) Abbot, C. G.
1927. A group of solar changes. Smithsonian Misc. Coll., V. 80, No. 2. Washington.
(22) Ångström, Anders.
1925. On radiation and climate. Geografiska Annaler. 4.1 och 2. Stockholm.
(23) Ångström, Anders.
1925. The albedo of various surfaces of ground. Geografiska Annaler. Arg. 7. H. 4, 323–342. Stockholm.
(24) Ångström, Anders.
1925. Evaporation and precipitation at various latitudes and the horizontal eddy conductivity of the atmosphere. Arkiv för matematik, Astronomi och Fysik. Bank 19 A, No. 20. Stockholm.

TORNADOES IN VIRGINIA, 1814–1925

ALBERT W. GILES

[University of Arkansas, Fayetteville, Ark.]

The compilation of a record of tornadoes and the construction of a tornado map is a difficult and unsatisfactory task. Not only are the necessary data widely scattered, but when assemblage from all available sources has been completed many interesting and often essential details are lacking. The phenomena involved are exceedingly transient, and the destructive results are quickly healed by man and nature. Therefore, unless the affected area is soon visited by a competent observer, much of the interesting detail and many of the unusual features are permanently lost, or survive only in the memory of the local inhabitants, always an uncertain index of what occurred.

Another difficulty is in interpretating correctly the character and motions of the destructive winds. Thunderstorm squalls may do considerable local damage leading to the belief that they were tornadic, yet they lack the gyratory motion of tornadic winds and can not be classed as such. Trained observers can readily detect the difference from the position and attitude of the débris, but unless a storm causes great property damage or casualties the area is rarely visited by such observers. In the following account an earnest effort has been made to exclude all storms that did not exhibit the phenomena characteristic of tornadoes.

The record for the earlier years is necessarily meager and brief due to uncertain and difficult means of communication, smaller population, and absence of a suitable agency for the collection and recording of weather data. The record is believed to be fairly complete since 1870, although probably a number of mild tornadoes in country districts have not been recorded.

In the preparation of the data all available sources have been utilized. Files of old newspapers have been consulted and clues have been profitably followed up by personal correspondence. The records of the Weather Bureau office in Richmond have been placed at the writer's disposal by Mr. E. A. Evans, in charge of that office. A number of accounts have appeared in the MONTHLY WEATHER REVIEW, and Mr. H. C. Hunter, of the Weather Bureau, has kindly assisted in making available from the files in Washington the record of a number of occurrences. The reports by Mr. J. P. Finley published in 1882 and 1885 by the United States Signal Service have supplied information concerning a number of Virginia tornadoes, and Mr. Finley has kindly supplemented this with details regarding 22 more recent occurrences. The annual reports of the Chief of the Weather Bureau, particularly for the years 1896 and 1897, have also yielded valuable data.

Table 1 gives all obtainable data for the 63 tornadoes recorded in Virginia to January 1, 1925. The order is chronological. The numbers in the first column are those of the tornado tracks the location and relative length of which are shown in Figure 1.

TABLE 1.—*Tornadoes reported in Virginia; earliest record (1814) to close of 1925*

No.	Date	County	Place	Time	Direction of movement	Length of path	Width of path	Tornado cloud	Number of persons: Killed	Number of persons: Injured	Property loss and remarks
						Miles	Feet				
1	Aug. 25, 1814	Loudoun	Leesburg [1]	3:30 p. m.	NE	6	[2] 600	Funnel		2	
2	July 27, 1816	Henrico	Manchester [1]	4 p. m.	NE	14	[2] 1,000	...do	2	3	Damage to buildings ($3,000). Dark cloud; rumbling noise.
3	May 16, 1834	Isle of Wight	Smithfield [1]	5 p. m.	E. 10° S	12	[2] 800	...do	3	4	Five buildings destroyed, timber, crops. Two clouds met in west and southwest.
4	June 21, 1834	James City	Lightfoot [1]	3 p. m.	E	10	[2] 1,200	Cone	1	3	Heavy damage to crops. Damage to buildings ($5,000). Loud roaring noise.
5	Mar. 4, 1842	Cumberland	Cartersville [1]	6 p. m.	NE	8	[2] 1,500	Funnel		3	Two clouds met in the West.
6	Mar. 19, 1857	Isle of Wight	Carrollton [1]	4:30 p. m.	ENE		[2] 500	Cone		2	Heavy damage to crops.
7	June 25, 1874	Smyth	Marion								
8	Aug. 23, 1875	Norfolk	Norfolk [1]								Hail before tornado.
9	July 13, 1876	...do	...do								
10	...do	Nottoway	Nottoway	P. m	NE	35					Rain and hail before tornado. Very dark clouds in Southwest and Northwest.
11	May 8, 1878	Bedford	Bunker Hill	P. m	NE	8					Heavy damage to timber; fallen trees blocking roads.
12	Sept. 12, 1878	Dinwiddie		P. m	NE		40-300	Funnel			Rain before, hail after tornado.
13	...do	Hanover		P. m	NE	15	[2] 375				Severe damage to crops and timber. Hail before tornado.
14	...do	Dinwiddie	Ford's Station	1:20 p. m	SE	45	40-300	Funnel			Heavy damage to timber and crops; several buildings destroyed. Rain and hail before tornado roaring noise.
15	...do	Goochland	Dover Mines [1]	4 p. m.	SE	28	300-700	...do			Terrible roaring noise. Light objects carried several miles.
16	Apr. 3, 1879	Halifax	Denniston [1]	3 p. m.	NE	5	[2] 1,000	...do		3	Severe damage to crops.
17	June 25, 1881	Rockingham	Port Republic	P. m	NE	6	3,000-6,000				Severe damage to crops.
18	Aug. 13, 1881	Dinwiddie	Petersburg	5 p. m.	NE	15	[2] ½ mile.	Cone			Heavy damage to crops. Houses unroofed, buildings damaged. Hail.
19	May 11, 1882	Southeast part of State.									Severe damage to crops. Several residences and barns destroyed.
20	June 4, 1882	Southhampton			S. or SW				2 in N. Ca.		Severe damage to crops. Several buildings damaged.
21	Aug. 21, 1884	Chesterfield	Nash [1]	6 p. m	ENE	12	[2] 1,000	Funnel			Much destruction to trees and buildings by hail.
22	Apr. 3, 1884	Campell	Evington	8 p. m.	ENE	8	[2] 1,800	Basket		2	Heavy damage to crops. Several buildings unroofed. Heavy electrical storm.
23	July 18, 1886	Lunenburg	Northern part	P. m.	NE		[2] 90	Funnel			Severe damage to timber. Several buildings damaged.
24	July 23, 1886	Accomac	Craddockville [1]	5 p. m	NE	6	[2] 800	...do	1	3	Severe damage to crops. Several buildings destroyed. Rumbling noise like railroad train.
25	Sept. 12-13, 1886.	...do	Ononcock	12-1 a. m.	NE	5	100-250	...do			Severe damage to timber and crops. Several houses destroyed, many unroofed. Loud roaring noise.
26	Apr. 18, 1887	Nansemond	Myrtle	6:30 p. m.	NE	6	300-600	...do	2	5	Severe damage to crops. Many houses, barns, etc., damaged. Total damage, $10,000.
27	June 21, 1887	Nottoway-Amelia			NE						Orchards and barns damaged.
28	July 23, 1887	Wythe	Wytheville	8:45 p. m				Funnel			Cloud did not touch earth.
29	Aug. 12, 1887	Rockbridge	Lexington	4 p. m.	NE	10	[2] 800	...do			Heavy damage to crops; several buildings unroofed. Damage, $5,000.
30	May 31, 1888	Nansemond	Buckhorn [1]	4 p. m.	NE	15	900-1,320	...do		3	
31	July 8, 1888	Fauquier	Hume [1]	9:30 p. m.	Easterly		[2] 2,640	...do	2	4	Heavy damage to crops. Two clouds met in the west.
32	Aug. 12, 1888	Rockingham	Cherry Grove [1]	Evening	Easterly	10	[2] 1,320	Cone		2	Crops, houses, and barns destroyed.
33	Sept. 10, 1888	Southampton	Sebrell [1]	4 p. m.	E		[2] 1,320	Funnel		2	Outbuildings destroyed.
34	...do	Nansemond	Elwood [1]	4:30 p. m.	ENE		[2] 800	...do	1	3	
35	...do	Isle of Wight	Windsor [1]	5 p. m.	NE	5	300-600	...do		4	Much damage to crops, and much damage to buildings.
36	Sept. 20, 1888	Orange	Unionville [1]	4 p. m.	NE	7	400-600	...do	1	3	Very destructive, many buildings damaged.
37	May 11, 1889	Cumberland	Northern part	4 p. m	NE	10	[2] 100		2	1	Small damage.
38	May 14, 1889	Pittsylvania	Danville	3:30 p. m.	ENE	13	[2] 1,300	Basket			Heavy damage to crops. Damage to buildings about $2,000.
39	May 29, 1890	Fauquier	Rectortown	3 p. m.	SE	12	900-1,200				Severe damage to timber and crops; several buildings damaged.
40	May 20, 1896	Mecklenburg	South Hill	5:30 p. m.	N		[2] 50				Damage, $2,000.
41	July 8, 1896	Sussex and Prince George.		5 p. m.	N	20	150-450			5	Damage, $1,200.
42	Aug. 18, 1904	Albemarle	Owensville	P. m.	Easterly	10	[2] 2,500	Funnel		1	Severe damage to buildings, crops, and timber.
43	Feb. 21, 1912	Fluvanna	Bremo Bluff	8:30 p. m.	SW. curving to NW.						Barns and stables unroofed; timber blown down.
44	May 12, 1912	Henrico	Richmond	12:30 p. m.	NE						Timber blown down; houses and barns unroofed.
45	...do	Campbell	Brookneal	4:30 p m.	NE						Timber blown down; buildings demolished.
46	Aug. 21, 1912	Northumberland	Avalon	3:30 p. m.	SE					2	Severe damage to timber, crops, and buildings.
47	May 12, 1913	Buckingham	Penlan		NE						Slight damage to timber.
48	Aug. 3, 1915	Dinwiddie	Petersburg	2:30 p. m.	N. and NE	40		Funnel			Damage to timber, crops and several buildings. Estimated damage, $10,000 or more.
49	...do	Caroline	Milford		NW	2	[2] 600	...do			Damage to timber and several buildings.
50	Oct. 29, 1917	Sussex	Jarratt	4 a. m	SE	8	[2] 900				Heavy damage to crops, and severe damage to buildings. Estimated damage, $10,000.
51	...do	Pittsylvania	Motley	10:30 p. m.	SE	2					Damage to timber, crops, and buildings.
52	...do	...do	Gretna [3]	10:40 p. m.	NNE	2	150-600		1	3	Heavy damage to buildings, estimated $50,000. Most destructive Virginia tornado.

[1] Near. [2] About. [3] Giles, Albert W.: A Virginia Tornado. MONTHLY WEATHER REVIEW, October, 1918, pp. 460-464.

TABLE 1.—*Tornadoes reported in Virginia; earliest record (1814) to close of 1925*—Continued

No.	Date	County	Place	Time	Direction of movement	Length of path	Width of path	Tornado cloud	Number of persons		Property loss and remarks
									Killed	Injured	
						Miles	*Feet*				
53	Apr. 30, 1918	Pittsylvania	Bachelors Hall	4 p. m.	E		[2] 300				Damage estimated at $1,600. Storm short-lived, moderate energy.
54	July 5, 1921	Albemarle	Cobham	2 p. m.	NE	2	[2] 1,500				Only slight damage.
55	Sept. 12, 1921	Augusta	Mint Spring		NE	5	[2] 300		0	2	Several large trees uprooted. One house demolished, another damaged. Total damage, $5,000.
56	Aug. 7, 1922	Albemarle [4]	Ivy	3 p. m.	SE	10	[2] 2,500	Funnel			Timber, crops, and several buildings damaged. Estimated damage, $5,000.
57	Apr. 30, 1924	Amelia	Maplewood [5]	5:30 p. m.	NE	10	300-900	do	1	12	Severe damage to crops. Forty buildings damaged or destroyed. Estimated loss, $20,000.
58	do	Greensville	Pleasant Shade [5]	5 p. m.	NE	½	[2] 125	do			One building destroyed; damage, $1,000. Tornado short-lived; slight energy.
59	July 2, 1925	Shenandoah	Mount Jackson	P. m.							Severe damage to orchards and crops by hail and wind. Tornado potential strongly developed. Estimated damage, $150,000.
60	July 4, 1925	Pittsylvania	Mount Hermon	P. m.	NE	2		Funnel			Severe damage to crops; several buildings damaged. Two funnel clouds converged.
61	July 26, 1925	Nansemond	Holland [1]	4 p. m.	ENE	16	[2] 900	do		5	Heavy damage to crops; several buildings destroyed.
62	do	Spotsylvania	Fredericksburg [1]	P. m.	NE	½	[2] 250	do			Small damage to buildings on one farm. Funnel cloud dipped down and swept across one farm.
63	Sept. 16, 1925	Pittsylvania	Whittles	P. m.	NE (?)	2		do			Church destroyed; dozen buildings damaged; small damage to crops. damage estimated, $6,000.

[1] Near.
[2] About.
[4] Giles, Albert W.: The Charlottesville, Virginia, Tornado of Aug. 7, 1922. MONTHLY WEATHER REVIEW, August, 1922, pp. 426-427.
[5] Hunter, H. C.: Tornadoes from Arkansas to Virginia, Apr. 29-30, 1924. MONTHLY WEATHER REVIEW, April, 1924. pp. 206-207.

The record previous to 1870 includes only six tornadoes, with none reported for the decades 1820–1830 and 1860–1870. Since 1870, 57 have been reported. The apparent increase is not due to greater frequency of tornadoes, but to increase in population, in facilities for obtaining reports, and a more intelligent popular interest in the weather. Table 2 shows the annual number of tornadoes from 1814 to the close of 1925, the years without them being omitted.

TABLE 2.—*Total number of tornadoes reported each year in Virginia, 1814–1925*

Year	Number	Year	Number
1814	1	1889	2
1816	1	1890	1
1834	2	1896	2
1842	1	1904	1
1857	1	1912	4
1874	1	1913	1
1875	1	1915	2
1876	2	1917	3
1878	5	1918	1
1879	1	1921	2
1881	2	1922	1
1882	2	1924	2
1884	2	1925	5
1886	3		
1887	4	Total (29 years)	63
1888	7		

The average yearly frequency, 1814–1925, was only 0.56. From 1870 to the close of 1925, a period when reports may be considered to be reasonably complete, the annual frequency was 1.02. And for the period 1916–1925 it was 1.4.

Virginia is not a leader among tornado States, but experiences enough of these storms to warrant the keeping of accurate tornado records. Table 3 compares tornado frequency in Virginia with that in several other States having roughly similar areas.

TABLE 3.—*Tornado frequency in Virginia and in a number of other States. (After Finley [1])*

State	Area	Number of recorded tornadoes
	Square miles	
Virginia	42,627	63
New York	49,204	144
Pennsylvania	45,126	145
West Virginia	24,170	19
Ohio	41,040	210
Indiana	36,354	154
Tennessee	42,022	99
Kentucky	40,598	84
North Carolina	52,426	108
South Carolina	30,989	120
Georgia	59,265	190
Florida	58,666	27
Alabama	51,998	283
Mississippi	46,865	138
Louisiana	48,506	71
Arkansas	53,335	199
Missouri	69,420	273
Oklahoma	70,057	149
Kansas	82,158	380
Iowa	56,147	285

[1] Finley, J. P.: Tornado occurrences and distributions. The National Underwriter, Apr. 1, 1926.

The tornado is typically American, and finds its real home in the great central lowlands of eastern United States. About 4,700 tornadoes have been recorded in the United States, nearly all occurring east of the Rockies. Uniformly distributed over United States, this is an average of 15.6 per unit area of 10,000 square miles. Virginia has an average of 14.8 for the same unit area. Tornadoes have been recorded in Virginia in every month except January. (See Table 4.) Fifty-five and four-tenths per cent of the reported tornadoes were confined to July, August, and September. May is also a tornado month. The number in June shows a marked decrease over the month preceding and the months following, an abnormality difficult to explain. Tornadoes are rare in

autumn and early spring. March and April, tornado months in the Mississippi Valley, include only 8, or 12.7 per cent, of those recorded in Virginia. October, with its three tornadoes, 4.8 per cent, shows a marked decrease over September.

TABLE 4.—*Total number and percentage of tornadoes recorded in Virginia by months, 1814–1925, inclusive*

Month	Number	Percentage	Month	Number	Percentage
January	0	0	July	13	20.4
February	1	1.6	August	11	17.5
March	2	3.2	September	11	17.5
April	6	9.6	October	3	4.8
May	11	17.5	November	0	0
June	5	7.9	December	0	0
				63	100.0

The occurrences by hours (so far as known) of tornadoes in Virginia are contained in Table 5.

TABLE 5.—*Hourly frequency of tornadoes in Virginia, 1814–1925, inclusive*

A. m.			P. m.		
Hour	Total number	Percentage	Hour	Total number	Percentage
12 to 1	1	2.4	12 to 1	1	2.4
1 to 2	0	0	1 to 2	1	2.4
2 to 3	0	0	2 to 3	2	4.8
3 to 4	0	0	3 to 4	7	16.7
4 to 5	1	2.4	4 to 5	12	28.5
5 to 6	0	0	5 to 6	8	19.0
6 to 7	0	0	6 to 7	3	7.1
7 to 8	0	0	7 to 8	0	0
8 to 9	0	0	8 to 9	3	7.1
9 to 10	0	0	9 to 10	1	2.4
10 to 11	0	0	10 to 11	2	4.8
11 to 12	0	0	11 to 12	0	0
				42	100.0

Hour uncertain, a. m.	0
Hour uncertain, p. m.	12
Hour unknown	9

The hour of occurrence of 42, or two-thirds, of Virginia tornadoes is known. Of the remaining 21, or one-third, 12 are known to have occurred between noon and midnight. Only 2 are known to have occurred between midnight and noon. The maximum is attained between 4 and 5 in the afternoon, with a rapid decrease in number before and after that hour. Nine of the 42 are reported as having occurred after 6 p. m. and only 6 before 3 p. m. This indicates a sharp increase after 3 p. m. and a more gradual decrease after 6 p. m. The "danger hours" are clearly between 3 and 6 p. m.

Tornadoes have not been uniformly distributed over the State. There is a marked tendency toward grouping in the southern Piedmont and southern Coastal Plain. West of the Blue Ridge they have been very rare, and they are sparsely spaced in the northern Piedmont and northern Coastal Plain. In the Coastal Plain province 21 have been recorded, in the Piedmont 31, west of the Blue Ridge, 7. Four crossed the fall belt from the Piedmont into the Coastal Plain. The localization of Virginia tornadoes essentially in the Piedmont and the Coastal Plain is brought out on the map (fig. 1). The reason for this concentration may be as follows: The tornadoes developed typically in the southern and southeastern parts of elongated LOWS with major axes, along which the wind-shift line is well developed, extending northeast-southwest. Hence the typical translation of the tornado northeastward (38 out of the 63 reported in Virginia moved thus) in these sectors of the LOW with the general northeastward progression of the LOW itself, and hence also the typical occurrence of the tornado near the wind-shift line. With the passage of the wind-shift line eastward the cooler westerly and northwesterly winds blow across the mountains over the warm air currents moving northeasterly at the surface of the Piedmont and Coastal Plain. The differences in direction of movement of the air currents and temperature contrast, together with local convection, are favorable both to thunderstorm and tornado development. These contrasts should become more marked southward due to increase in altitude of the Appalachians and to higher temperatures of the surface currents. This seems to explain the increase in tornado frequency southward in Virginia and in the Piedmont and Coastal Plain of southeastern United States.

Six tornadoes moved eastward, 8 southeast, 1 south or southwest, 1 northwest, and 3 northward. The directions of movement of 6 are unknown. Data are not at hand to explain departures from normal direction of translation. Eastward and southeastward movements are produced in some cases when the tornado develops in the southwest quadrant of the LOW, where the prevailing wind direction is from the northwest.

The length of paths pursued by 21 of the tornadoes is not known; of the remaining 42 the average length of path was 11 miles. Rarely were they more than 12 miles long, and 12, or 28 per cent, were 5 miles or less in length. The tornado of September 12, 1878 (No. 14), that passed through Fords Station in Dinwiddie County had a path 45 miles long, and that of August 3, 1915 (No. 48), traversing east Dinwiddie County, had a path 40 miles long. The length of the path of the Nottoway tornado (No. 10), was 35 miles, and of the Goochland tornado (No. 15), 28 miles in a southeast direction. The other tornadoes had paths of 20 miles or less in length.

The widths of 44 tornado tracks in Virginia averaged 930 feet, while the average width of American tornado paths (zone of severe destruction) is 1,200 feet. Only 5 of the 44 had paths as wide as 2,500 feet, only 11 had paths wider than 1,200 feet, and 13 had paths 500 feet wide or less.

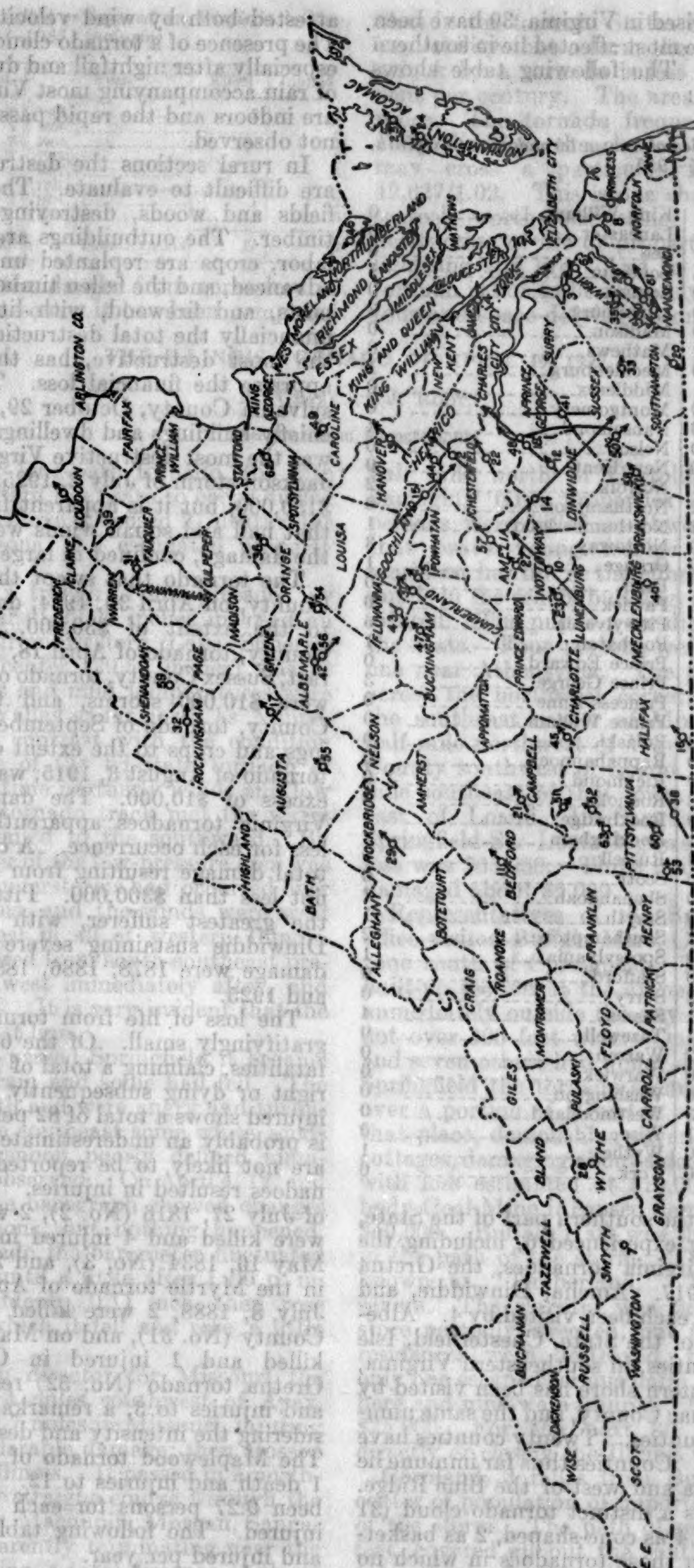

FIG. 1.—Tornadoes in Virginia. (Arrows show approximate direction of tornado travel, where known)

Of the 100 counties comprised in Virginia, 39 have been visited by tornadoes. Those most affected lie in southern and southeastern Virginia. The following table shows the distribution by counties:

TABLE 6.—*Distribution by counties of known tornadoes in Virginia, 1914–1925*

Accomac	2	King William	0
Albemarle	3	Lancaster	0
Alleghany	0	Lee	0
Amelia	4	Loudoun	1
Amherst	0	Louisa	0
Appomattox	0	Lunenburg	2
Arlington	0	Madison	0
Augusta	1	Mathews	0
Bath	0	Mecklenburg	1
Bedford	1	Middlesex	0
Bland	0	Montgomery	0
Botetourt	0	Nansemond	4
Brunswick	0	Nelson	0
Buchanan	0	New Kent	0
Buckingham	1	Norfolk	2
Campbell	2	Northampton	0
Caroline	1	Northumberland	1
Carroll	0	Nottoway	3
Charles City	0	Orange	1
Charlotte	0	Page	0
Chesterfield	3	Patrick	0
Clarke	0	Pittsylvania	6
Craig	0	Powhatan	1
Culpeper	0	Prince Edward	0
Cumberland	2	Prince George	3
Dickenson	0	Princess Anne	0
Dinwiddie	4	Prince William	0
Elizabeth City	0	Pulaski	0
Essex	0	Rappahannock	0
Fairfax	0	Richmond	0
Fauquier	2	Roanoke	0
Floyd	0	Rockbridge	1
Fluvanna	1	Rockingham	2
Franklin	0	Russell	0
Frederick	0	Scott	0
Giles	0	Shenandoah	1
Gloucester	0	Smyth	1
Goochland	2	Southampton	2
Grayson	0	Spotsylvania	1
Greene	0	Stafford	0
Greensville	2	Surry	0
Halifax	1	Sussex	4
Hanover	1	Tazewell	0
Henrico	2	Warren	0
Henry	0	Warwick	0
Highland	0	Washington	0
Isle of Wight	3	Westmoreland	0
James City	1	Wise	0
King and Queen	0	Wythe	1
King George	0	York	0

Pittsylvania County, in the southern part of the State, leads in tornadoes, having experienced 6, including the most destructive of all Virginia tornadoes, the Gretna tornado of October 29, 1917. Amelia, Dinwiddie, and Nansemond Counties have each been visited by 4. Albemarle, in the central part of the State, Chesterfield, Isle of Wight, and Sussex Counties, in southeastern Virginia, have had 3 each. The eastern shore has been visited by 2 tornadoes, both in Accomac County, and the same number has visited 10 other counties. Twenty counties have had but a single visitation. Counties thus far immune lie chiefly in northern Virginia and west of the Blue Ridge.

In 37 Virginia tornadoes a distinct tornado cloud (31 reported as funnel-shaped, 4 as cone-shaped, 2 as basket-shaped) was observed. In those tornadoes in which no such cloud was seen, tornadic violence was strongly attested both by wind velocity and destructive effects. The presence of a tornado cloud is likely to be overlooked, especially after nightfall and during the heavy downpours of rain accompanying most Virginia tornadoes, for people are indoors and the rapid passage of the tornado cloud is not observed.

In rural sections the destructive effects of tornadoes are difficult to evaluate. The tornado sweeps through fields and woods, destroying outbuildings, crops, and timber. The outbuildings are quickly repaired by local labor, crops are replanted unless the season be too far advanced, and the fallen timber is converted into lumber, posts, and firewood, with little thought of estimating financially the total destruction. In only a few storms, the most destructive, has there been any attempt to appraise the financial loss. The Gretna tornado, Pittsylvania County, October 29, 1917, destroyed property, chiefly buildings and dwellings, valued at $50,000. This was the most destructive Virginia tornado. The Mount Jackson storm of July 2, 1925, caused a loss estimated at $150,000, but it is apparent from the newspaper reports that hail and squall winds were responsible for much of the damage, confined in large part to orchards.

The tornado that swept through Maplewood, Amelia County, on April 30, 1924, damaged buildings and crops to the extent of $30,000. The Myrtle, Nansemond County, tornado of April 18, 1887 (No. 26), and the Jarratt, Sussex County, tornado of October 29, 1917 (No. 50), were $10,000 storms, and the Whittles, Pittsylvania County, tornado of September 16, 1925, damaged buildings and crops to the extent of $6,000. The Petersburg tornado of August 3, 1915, was responsible for damage in excess of $10,000. The damage resulting from other Virginia tornadoes apparently amounted to $5,000 or less for each occurrence. A conservative estimate of the total damage resulting from all tornadoes in Virginia is not less than $300,000. Pittsylvania County has been the greatest sufferer, with Amelia, Nansemond, and Dinwiddie sustaining severe losses. Years of severest damage were 1878, 1886, 1887, 1888, 1915, 1917, 1924, and 1925.

The loss of life from tornadoes in Virginia has been gratifyingly small. Of the 63 tornadoes, 11 resulted in fatalities, claiming a total of 17 persons either killed outright or dying subsequently from injuries. The list of injured shows a total of 82 persons, although this number is probably an underestimate, for cases of minor injuries are not likely to be reported. Twenty-five of the tornadoes resulted in injuries. In the Manchester tornado of July 27, 1816 (No. 2), 2 were killed and 3 injured; 3 were killed and 4 injured in the Smithfield tornado of May 16, 1834 (No. 3), and 2 were killed and 5 injured in the Myrtle tornado of April 18, 1887 (No. 26). On July 8, 1888, 2 were killed and 4 injured in Fauquier County (No. 31), and on May 11, 1889 (No. 37), 2 were killed and 1 injured in Cumberland County. The Gretna tornado (No. 52) resulted in the loss of 1 life and injuries to 3, a remarkably small casualty list considering the intensity and destructiveness of the tornado. The Maplewood tornado of April 30, 1924, resulted in 1 death and injuries to 12. The average death toll has been 0.27 persons for each tornado, with 1.30 persons injured. The following table shows the number killed and injured per year.

Table 7.—*Number of persons killed or injured in Virginia by tornadoes, 1814–1925, inclusive*

Year	Killed	Injured	Year	Killed	Injured
1814		2	1880	2	1
1816	2	3	1896		5
1834	4	7	1904		1
1842		3	1912		2
1857		2	1917	1	3
1879		3	1921		2
1884		2	1924	1	12
1886	1	3	1925		5
1887	2	5			
1888	4	21	Total	17	82

Table 7 indicates that the danger from tornadoes in Virginia is not great. Moreover, it has been computed that in the tornado States in the Mississippi Valley the probability that a farm the size of 1 square mile will be struck by a tornado is less than one-sixteenth of 1 per cent per century. The area of Virginia is 42,617 square miles. The tornado frequency per year since 1870 is 1.02; therefore the chance that a tornado in any year may cross a particular locality 1 mile square is 42,627/1.02. This is one chance in 41,000, and hence is scarcely worth considering. The probability of tornado destruction of life or property is far less than that from lightning and fire. And so far as life is concerned, the tornado is not to be remotely compared with the ubiquitous and space-defying automobile.

THE ILLINOIS TORNADO OF APRIL 19, 1927

By Clarence J. Root,

[Weather Bureau, Springfield, Ill.]

Illinois has had another long-path tornado, the fifth of more than 100 miles within the State to occur during the last 10 years. In its course it caused 21 deaths, the known injury of 183 persons, and estimated property losses of $1,369,500.

At 7 a. m. of the 19th a trough of low pressure lay west of Illinois. The isobar of 29.60 inches inclosed an elongated area extending from western Lake Superior to eastern Kansas. The center (29.50 inches) was at St. Paul. Southerly winds and mild temperatures were general in the Mississippi Valley as far north as Minnesota. This was in direct contrast with the condition that obtained at the time of the tri-State tornado of March 18, 1925. At that time northerly winds and low temperature north of the tornado track met the warm southerly winds that prevailed to the southward. By 7 p. m. of the 19th the center of the low-pressure area was north of Lake Superior, thunderstorms had occurred over northern and central Illinois, and the winds were west at Springfield and northwest in all of western Illinois. At Springfield the wind veered from south-southeast preceding the storm to southwest immediately after, and later to west and northwest. It is very evident that the tornado occurred on the shift line.

At the time the tornado passed Springfield it became quite dark, and excessive rain and some hail fell. The clouds moved from the south and were angry and turbulent in appearance. In the southeast some white scuds appeared. During the forenoon poorly defined mammato-cumulus clouds were observed. On April 4, 12, and the morning of the 19th the barograph showed changes typical of tornadic conditions, but nothing happened. About the time of the tornado the barometer fluctuated considerably. From noon until a little after 1:00 p. m. it fell rapidly, but not suddenly, 0.11 inch, then rose suddenly 0.10 inch, after which it fell and rose a little before 2:00 p. m.

According to the section director for Missouri the tornado had its inception 4 miles southwest of Apex, Lincoln County. It moved 7 miles in Missouri, injuring 12 persons and doing considerable damage; then crossed the Mississippi River into Illinois. It passed in a northeast direction over a nearly straight course through the counties of Calhoun, Greene, Macoupin, Morgan, Sangamon, Logan, De Witt, apparently terminating near the Ford-Livingston boundary line, a total distance of about 170 miles.

Two lives were lost in Calhoun County, the narrow peninsula between the Illinois and Mississippi Rivers. The storm passed one-half mile northwest of Hardin and crossed Greene County with no skipping, passing one-half mile north of Carrollton, the county seat, and damaging farm properties across the county. Three persons were killed southwest of Carrollton, including that brave young teacher, Miss Annie Keller, who sacrificed her life in the effort to save the lives of the 18 pupils in the school building, none of whom was seriously injured. The pupils were directed to take shelter under the seats. Four persons were killed near Wrights, and one near Athensville. The path of the storm then led across the northwest corner of Macoupin County and the southeast corner of Morgan County, passing one-half mile northwest of Waverly, and entered Sangamon County southwest of Loami. It passed only one-fourth mile southeast of that town. A death occurred 2 miles east of Loami. In Sangamon County west of the Springfield-St. Louis highway (route 4) the property loss was $65,000. Three buildings at the highway were damaged about $6,000.

Representatives of the Springfield Weather Bureau office visited Buffalo Hart, Cornland, Riverton, and the zone south of Springfield. The next damage was in a built-up section at the extreme southeast of Springfield, immediately outside the city limits. The path here was not over 300 feet wide. One house was moved 7 feet, and seven others had minor damage. Soon after leaving Springfield the tornado seemed to lift and after passing over a portion of Riverton struck the northeast part of that place, demolishing seven dwellings, mostly miners' cottages, damaging about a dozen more, six of them badly, with loss estimated at $10,000; then striking the Peabody Coal Mine it caused damage to the extent of about $40,000. Buffalo Hart was the first town to lie directly in the path of the storm. This hamlet is in the woods known as "Timberland." The tree destruction was severe. The elevator was turned over, the depot and store partially wrecked, but the church escaped. Five residences were destroyed, five badly damaged, and only one escaped serious harm. There were three deaths here and nine were injured. The money loss was about $35,000. For the next 30 miles the path followed directly or closely the Illinois Central Railroad.

Cornland, 3 miles from Buffalo Hart, was the only center of population of importance that felt the full fury of the storm. The path of severe damage, about 1,000 feet, covered all but the south edge of the town. The total width of the path here was about 2,000 feet. Of the 48 residences, 5 were very little harmed, 7 were a total loss, and the other 36 received varying degrees of damage. The 2 churches and 5 stores were destroyed, the bank partly wrecked, but the 2 elevators, depot, and 2 school buildings received very little injury. The total

damage was at least $100,000. Two persons were killed and five injured. Considering the destruction at Cornland, it is remarkable that there were no more casualties. After leaving Cornland the path lay south of Lake Fork, just at the south edge of Mount Pulaski, through Chestnut, at the north edge of Clinton, within 1 mile of the courthouse. The tornado passed through one corner of Le Roy, causing a loss of $100,000, including the damage to the high-school building; then it moved on between Arrowsmith and Saybrook. A number of persons were injured in the Le Roy school building. Two persons were killed near Mount Pulaski. At Chestnut it damaged property $60,000, including $10,000 loss to a modern two-story brick school; two of the pupils were killed. A farmer lost his life in De Witt County.

Perhaps the most peculiar feature of this tornado was the manner in which it just missed cities and towns along its course, as indicated in the table below (Table 1). The tri-State storm of 1925 acted in a very different manner. Had the recent storm passed through the centers of population listed in the table, the deaths and losses would have been several times greater.

TABLE 1

Place	Population (1920)	Distance from (miles)
Hardin	694	½
Carrollton	2,020	½
Waverly	1,510	½
Loami	462	¼
Springfield	59,183	[1] ½
Riverton	1,916	([2])
Lake Fork	100	¾
Mount Pulaski	1,510	¼
Clinton	5,988	[3] 1

[1] From city limits.
[2] Passed over part of Riverton, but struck northeast corner.
[3] One mile from courthouse.

The path of the tornado varied in width from 200 to 2,000 feet. In some parts of its course a funnel-shaped cloud was reported. A State official, from the sixth floor of the capitol building, saw a distinct funnel cloud, lifting from the ground at times. In the suburbs of Springfield, where the path was narrow, a witness, one-half block from the path, saw a small funnel cloud. At Buffalo Hart and Cornland, where the path was wide, we could find no one who observed such a cloud. They spoke of boiling dark clouds, and some mentioned a cloud "rolling toward them." In connection with the May, 1917, and March, 1925, tornadoes[1] the writer suggested that the cloud was so close to the earth there was no room for the usual pendant portion. Here we have: Narrow path—funnel cloud; wide path—no funnel cloud. Hail fell in connection with the storm.

The direction of movement was northeast 7° east, and there were only slight variations from that direction. In part, the time of passage was secured from train dispatchers, being the time the wires went out. It passed Hardin about 12:00 noon; Wrights, about 12:25 p.m., Waverly, 12:50 p. m.; Springfield, about 1:10–1:15 p. m.; Buffalo Hart, 1:27 p. m.; Cornland, 1:30 p. m.; Clinton, 1:55 p. m.; Sibley, about 2:30 p. m. Some of these times are approximate, but using those that are believed to be exact it is found that the average velocity of translation, on a direct course, was 60 or 61 miles per hour. The Mattoon tornado of 1917 traveled at 40 miles per hour, and the great 1925 storm at 59 miles per hour.

The storm was continuous over much of its track, but there was some lifting and skipping. There were not many evidences of explosive force. At Buffalo Hart and Cornland trees and débris lay mostly to the northeast and north. In many cases, however, they lay to the southeast, and this appeared to be where the damage was most severe. We found no trees lying in the direction from which the storm had come. This storm lacked the severity of the great tornado of March, 1925. At Cornland we saw a 1 by 5 board driven well into a window casing. A private garage was entirely destroyed and carried away, but a new car was not moved or even scratched; near Le Roy a barn was carried away, but the horses, tied to the manger, were left standing and unhurt. Débris fell at Alexander, 10 miles to the left of the storm track.

The subjoined table (Table 2) is a statement by counties of the deaths, the number injured, and the property losses.

TABLE 2

County	Deaths	Known injured	Orchard loss	Other property
Lincoln, Mo.	0	12	$1,000	$20,000
Calhoun	2	21	15,000	35,000
Greene	8	23	None.	200,000
Macoupin	0	3	4,000	100,000
Morgan	0	4	2,500	100,000
Sangamon	4	22	6,000	183,000
Logan	6	14		247,000
De Witt	1	9	1,000	200,000
McLean	0	15	10,000	210,000
Ford	0		Minor.	35,000
Total	21	123	39,500	1,330,000

[1] See MONTHLY WEATHER REVIEW, June, 1917, 45: 294; August, 1924, 52: 396; November, 1924, p. 542; April, 1925, 53: 144.

TORNADOES IN ARKANSAS, 1879–1926

By HARVEY S. COLE

[Weather Bureau, Little Rock, Ark.]

SYNOPSIS

The article presents three tables: One showing the place, date, and certain statistics regarding 225 tornadoes which occurred in Arkansas from 1879 to 1926; one showing the distribution of tornadoes by months and years; one showing the number of tornadoes by months from 1908 to 1926, the number of thunderstorms in Little Rock for the same period, and a comparison of tornadoes in Arkansas and thunderstorms at Little Rock. A chart showing the distribution of tornadoes over the State is given with arrows showing the direction of tornadoes at Fort Smith, Little Rock, Heber Springs, and Hot Springs.

The chart and tables are discussed, also some of the larger features of topography and their probable effect on the courses and distribution of tornadoes. It is pointed out that tornadoes usually form in the southeastern portion of the LOW and move northeastward; and reasons are given for the movement of some tornadoes in other directions and for the occurrence of tornado families.

Records of meteorological data in Arkansas before 1879 are very scarce, and if there are any concerning tornadoes before that date the writer has not been able to find them. Table 1 includes the place, date, time, width of path, direction from which the storm came, the number killed and injured, and all obtainable estimates of the value of the property destroyed for all tornadoes in Arkansas of

which we have a record for the years 1879 to 1926. Table 2 gives the number of tornadoes by months and for years, also totals at the bottom for the entire number of years and for the years 1908 to 1926. Table 3 gives the tornadoes by months for the period 1908 to 1926, the number of thunderstorms at Little Rock by months for the same period, the number of thunderstorms per tornado, and the number of tornadoes per year for each month of the year.

The data for Table 1 were obtained from the Daily Journal at Little Rock, Finley's Tornado Studies of 1884, Finley's Character of 600 Tornadoes, and Climatological Data for Arkansas. The table includes a record of tornadoes at 225 different towns or communities from 1879 to 1926. In some instances one tornado passed through several towns, all of which are named, in others the tornado passed through several towns or communities and only one of them is named. From 1908 to 1926 the record is fairly complete, but it is thought that before that time only a small portion of them were recorded. None was recorded from 1888 to 1891 or from 1902 to 1907. From 1879 to 1907 the average number per year was 1.1, from 1908 to 1926 it was 10.1 per year, indicating that the earlier record was incomplete. It is thought that the entire record should be used in determining the distribution by months, but only the record from 1908 to 1926 should be used in determining the number per year.

No regularity in the annual number of tornadoes is found. In 1908 there were 11; in 1909, 27; in 1910, none; in 1911, 2; in 1912, 11, etc.

In the tabulation of tornadoes by months we find the numbers rather large in November, March, and April and June, small in the remaining months. The greatest number for any month for the 48-year period is 52 in March, 51 being reported in April, 45 in November, and 39 for June.

It is evident from Table 3 that the number of tornadoes for the different months does not vary as the number of thunderstorms at Little Rock.[1] Tornadoes are frequent from February to June, few in other months; thunderstorms are frequent from March to September. Thunderstorms nearly always occur with tornadoes, but tornadoes are rare from July to October, while thunderstorms are more frequent in July than in any other month, the numbers being large for the other three months. The number of tornadoes in Arkansas and the number of thunderstorms at Little Rock for March and April were charted for the years 1908 to 1926 and lines drawn through the dots. A decided relation was found, the lines nearly always rising and falling together. There were six years from 1908 to 1926 with no tornadoes in these months, the number of thunderstorms being less than the average in five of them. Six of the seven years having more than the average number of tornadoes had more than the average number of thunderstorms.

The places at which tornadoes have been reported from 1879 to 1926 have been represented as nearly as practicable by dots on a map of Arkansas in Figure 1, two or more dots being placed near together when two or more tornadoes were reported at the same place. In places where a tornado traveled a long distance a line has been drawn.

We find that more tornadoes have been reported in the more densely populated sections than elsewhere. There are three rather large areas with few dots, one in the northern mountainous portion, one in the mountains south of the Arkansas River, and one in the level portion in the southeast. All of these areas are sparsely populated. The low, level area east of the highlands from the Arkansas Valley northward is well covered with dots. For the lack of reports of tornadoes farther south there seems to be no reason except the lack of population.

Four dots appear at Fort Smith and Little Rock, three at Heber Springs, Hot Springs, Jonesboro, Ozark, Piney, Stuttgart, and Texarkana. Fort Smith is west of the Ozarks, Little Rock just east of the foothills. Heber Springs, Hot Springs, Ozark, and Piney are in the mountains, Jonesboro, Stuttgart, and Texarkana are in the lowlands where contour can have no effect. Six of the places having three or more tornadoes are in the mountains or the edge of the foothills; only three in level country.

Arrows have been drawn to indicate the direction of the paths of four tornadoes at Little Rock, in Figure 1. The tornado of October 2, 1894, moved directly from the west through the business section. The other three moved from the southwest, the ones of June 5, 1916, and May 14, 1923, being about 4 miles west of the business district, the one of December 8, 1885, about 2½ miles west. The storms of 1916 and 1923 were so near each other that they overlapped throughout most of their length. As nearly as we can learn all of these storms stopped near the river bank, this being the only indication of the effect of contour on the courses of the storms.

Arrows have been drawn in Figure 1 showing the direction of the paths of four tornadoes at Fort Smith. The one of June 27, 1879, came from the northwest, passing through the business district. The tornadoes of January 12, 1898, May 28, 1924, and April 23, 1926, came from the west, two of them passing through the business district, the third through the northern edge of the city, 2 miles from the business center. Tornadoes in Arkansas and Oklahoma nearly always move from southwest to northeast, but three of those at Fort Smith are from the west and one from the northwest. In this connection attention is called to the fact that the prevailing winds at Fort Smith are from the east throughout the year. At nearly all stations in Arkansas the prevailing winds are from some southerly direction during the warmer months, from the north or northwest during the remainder of the year. It is pretty well established by Mr. T. G. Shipman and others that the unusual direction of the wind at Fort Smith is due to contour—not the little local hills, but to Boston Mountain to the north, and passes between Mount Magazine and other mountains to the south and east. Boston Mountain extends nearly east and west for nearly 100 miles. It rises abruptly just north of the Arkansas River to an elevation of 2,000 feet or more throughout nearly its length, forming an abrupt barrier to southerly winds. Many more dots are found to the south and around the east and west ends of this mountain than just north of it, indicating that the mountain has some effect on the courses of the tornadoes.

Arrows in Figure 1 indicate the direction of three tornadoes at Heber Springs. All of these came from the west-southwest, each one coming slightly nearer the business district, the paths of the three overlapping each other. Their direction is not quite the same as that of most tornadoes in Arkansas, and the one of November 25, 1926, changed its course slightly, as it came from Greenbrier, due southwest of Heber Springs. The three storms passed over nearly the same spot in 17 years, moving in nearly the same direction. It is thought that currents from the southwest striking a sharp ridge like Boston Mountain would be deflected toward the east, the currents up to 2,000 feet or more being affected.

[1] This is true for the southern and southeastern States in general.—Ed.

FIG. 1.—Tornadoes in Arkansas, 1879-1926

Key numbers for tornado tracks:
1. Tornadoes, Little Rock, December 8, 1885, October 2, 1894, June 5, 1916, and May 14, 1923.
2. Tornadoes, Fort Smith, July 7, 1894, January 12, 1898, May 28, 1924, May 23, 1926.
3. Tornadoes, Hot Springs, November 25, 1915, June 5, 1916, and September 9, 1924.
4. Tornadoes, Heber Springs, April 29, 1909, June 5, 1916, and November 25, 1926.
5. Tornado, McCreanor to Waldenberg, February 23, 1909.
6. Tornado, Malvern to Galloway, March 8, 1909.
7. Tornado, Mineola, Tex., to Mount Pisga Settlement, Ark., April 17, 1921.
8. Tornadoes, Belleville to Mars Hill, Greenbrier to Heber Springs, and Jessieville to Greenbrier, November 25, 1926.
9. Tornado, Leola to Des Arc, December 26, 1916.
10. Tornado, Mickles to Piney, April 18, 1920.

This would probably deflect tornadoes somewhat to the east of the courses they would otherwise have followed. Dots are much more numerous just east, south, and west of Boston Mountain than they are north of it, which seems to bear out this opinion. It is probable, however, that Heber Springs is in no more danger of being in the path of a tornado than any other town in that section of the country.

Arrows in Figure 1 also represent the paths of three tornadoes at Hot Springs. The one of November 25, 1915, came from a little west of south. It was a severe storm, doing great damage. Two men stood on North Mountain and watched it moving up the valley toward Hot Springs. The balloon-shaped cloud moved steadily forward to the edge of town, the ropelike spout swaying from side to side as it approached. After reaching the edge of town it changed its course a little more toward the northeast. It crossed a series of ridges and ravines. As it moved up the side of a ravine the lower end of the spout was ground off, but it built downward as it moved

down the next slope, reaching the ground again as it started up the next; this was repeated several times. When the spout reached the ground the débris would fly, when it started down the next slope the débris would fall out, but little damage was done until it started up the next slope. The same was noted in the storm at Heber Springs of November 25, 1926. A dwelling stood in a ravine across which the tornado passed. The upper portion of the house was entirely destroyed, but the lower story was left standing nearly intact. The tornado at Hot Springs may have changed its course because of the mountains in front of it, but it crossed Indian Mountain a few miles northeast of Hot Springs. The storms of June 5, 1916, and September 29, 1924, were from the southwest and passed through the central portion of the town, but they were small, doing but little damage.

The direction of movement of 123 tornadoes is given in Table 1. One hundred and two of these were from the southwest, 13 from the west, 4 from the northwest, 2 from the south, 1 from the north, and 1 from the northeast, the only directions not represented being the east and southeast. The numbers of tornadoes from the different directions as shown in the charts in the annual report of the chief of the bureau seem to have nearly the same distribution.

Tornadoes are nearly always formed in the southeastern quadrant of the LOW and follow courses slightly to the right of the isobars. Several tornadoes frequently form along the edge of the cold current that causes them. The current follows the isobars, but the eastward movement of the LOW gives them a northeastward movement with parallel paths, thus forming tornado groups or families. Thus tornadoes were reported in five localities on April 18, 1880, in 11 on November 23, 1908, in 13 on March 8, 1909, in 7 on April 29, 1909, in 12 on March 20, 1913, in 34 on June 5, 1916, and in 27 on November 25, 1926. The cold currents come far enough south to cause tornadoes in Arkansas from November to June, but very few have been recorded in other months. As the season advances and the courses of HIGHS and LOWS move northward; the area of tornado activity also moves northward.

The approximate time of occurrence is given for 140 of the tornadoes in Table 1. One hundred and seven of these occurred from noon to midnight, 30 from midnight to noon, and 69 from 3:00 p. m. to 8:00 p. m. From 6:00 p. m. to 8:00 p. m. seems to be the time of greatest frequency, 38 being recorded in those two hours, 35 being reported from 5:00 p. m. to 7:00 p. m., 31 from 4:00 p. m. to 6:00 p. m., and 25 from 3:00 p. m. to 5:00 p. m.

The number of persons killed in Arkansas by tornadoes in the past 48 years as shown in the table is 549, or 11.4 per year. The number reported injured in that time was 2,246, and the value of the property destroyed over $6,000,000. A glance at the table will show that these numbers are probably far short of what actually occurred, especially the number of injured and the value of property destroyed.

The average width of the paths reported is about 630 feet. Their lengths can not be determined with any certainty from the few reported, but they seem to be usually only a few miles long. In tornado groups, several storms doubtless form near the same time, one northeast of the other. If is likely that the ones that form first die out first, the later ones successively increasing and then decreasing in intensity. This would give them such a distribution as we find in the storms of June 5, 1916, and November 25, 1926.

CONCLUSIONS

The distribution of tornadoes in Arkansas appears to be rather even except on the northern side of the higher mountains, where few have been reported.

Small features of topography offer some protection to buildings when located behind hills or in ravines across which the tornado passes. Protection should be against storms coming from the southwest or west. Special care should be taken in November and March to June. Large topographic features, such as mountains rising abruptly 1,000 feet or more in front of tornadoes, seem to divert their courses.

It is thought that one small town is no more apt to be in the path of a tornado than any other in that general section of the country, but that towns north of Boston Mountain are not as apt to be in the path of such a storm as towns east, south, and west of that mountain.

TABLE 1.—*Tornadoes and tornado groups in Arkansas, 1879–1926*

Place	Date	Hour	Width	From—	Killed	Injured	Damage
			Feet				
Fort Smith	June 27, 1879	P. m.		N-NW			Several houses.
Washington County	Apr. 18, 1880	8:30 p. m.	200	SW	2	20	$100,000.
Franklin County	do	6:40 p. m.		SW			Great damage.
Eureka Springs	do	P. m.		SW			18 houses destroyed.
White County	do	8 p. m.	1,200	SW	10	20	
Dardanelle	do	8 p. m.		SW			Town partly destroyed.
Monroe County	Apr. 12, 1881	2 p. m.		SW			
Franklin County	Apr. 13, 1883	11:00 p. m.		SW	4	Few.	$22,000.
Conway	Apr. 14, 1883	3:15 p. m.		NE	0	3	$50,000.
Fort Smith, 15 miles SW. of	July 7, 1884	8:20 p. m.		NW			
Searcy	May 5, 1884				0	1	Several buildings.
Little Rock	Dec. 8, 1885	P. m.	150	SW	0	0	$250.
Ozark	Apr. 22, 1887						Destructive.
Durham	Nov. 16, 1892				0		Much damage.
Harrison	do				3		Do.
Fayetteville	Apr. 19, 1893				0		Do.
Ozark	do				0		Do.
Little Rock	Oct. 2, 1894	8:28 p. m.	300	W	4	26	$150,000.
East Jefferson County	Oct. 29, 1896				0		Much damage.
Benton	Jan. 2, 1897	7 p. m.		SW	1		$50,000.
Cameron	do				1		
Hope	Mar. 2, 1897						Considerable damage.
Cleveland County	Mar. 31, 1897						Much damage.
Grady	do						Do.
Fort Smith	Jan. 12, 1898	12:08 a. m.	600	W	52	44	$450,000.
Alma	Jan. 11, 1898	11 p. m.	600	W	0	0	$2,000.
Batesville	July 2, 1898	1 p. m.			1	3	One building destroyed.
Robroy	Mar. 1, 1899	A. m.	100	NW	1		$2,500.
Forest City	Mar. 9, 1901						
Rockyhill	do						
Osceola	do				16		
Texarkana	do						
Washington	do						

TABLE 1.—*Tornadoes and tornado groups in Arkansas, 1879–1926*—Continued

Place	Date	Hour	Width	From—	Killed	Injured	Damage
			Feet				
Watulla	Nov. 23, 1908			SW	14		
Jethro	do			SW	2		
Potter	do			SW	1		
Mulberry	do			SW	1		
McNeil	do			SW	0		
Berryville	do			SW	0		
Piney	do			SW	0		
London	do			SW	0		$100,000.
Canfield	do			SW	0		
Walcott	Nov. 25, 1908	3:30 p. m.	450	SW	1	5	$20,000.
Lorado	do	4 p. m.	300	SW	1	4	$30,000.
Hamburg	Feb. 5, 1909	8 a. m.			0	0	$6,000.
Stuttgart	do	8 a. m.			2	0	$15,000.
McCreanor to Waldenberg	Feb. 23, 1909	2 a. m.	5,000	SW	9	107	$106,300.
Alexander Farm	Mar. 8, 1909	7 p. m.		SW			
Brinkley	do	7 p. m.		SW			
England	do	7 p. m.		SW			
Princeton	do	7 p. m.		SW	55	625	$608,000.
Hazen	do	7 p. m.		SW			
Sheridan	do	7 p. m.		SW			
Witherspoon	do	8 p. m.		SW			
Malvern	do	8 p. m.		SW			
Gilford	do	8 p. m.		SW			
Benton	do	8 p. m.		SW	10	50	$30,000.
Brooks	do	8 p. m.		SW			
Fourch Dam	do	8 p. m.		SW			
Galloway	do	8 p. m.		SW			
Hunter	Apr. 6, 1909	12:10 p. m.	1,300	SW	0	0	$2,000.
Cotton Plant	do	1 p. m.		SW			$5,000.
Catcher	Apr. 29, 1909	4:40 p. m.		SW			
Piney	do			SW			
Heber Springs	do			SW			
Palestine	do			SW	10	148	$178,000.
Crawfordsville	do			SW			
Caddo Gap	do			SW			
Marianna	do			SW			
Mena	Apr. 13, 1911	9:15 p. m.	300	W			$30,000.
Wooster	Apr. 14, 1911	1 a. m.			3		
Arkansas, Lee, and St. Francis Counties	Feb. 25, 1912				18		$100,000.
Star City	Apr. (?), 1912						
Keo	do						
Lutherville	do						
Fouk	do				2	13	Considerable.
McGehee	do						
Loueburg	do						
Junction	do						
Booneville	Aug. 3, 1912	11:45 p. m.	Few.	SW	0	6	$60,000.
Caledonia	Mar. 13, 1913						
Hibank	do	9 a. m.	300		1	47	$24,000.
Blanchard Spring	do						
Hoxie and Walnut Ridge	Mar. 20, 1913	9:30 a. m.					
Brinkley	do	9:30 a. m.					
Wynne	do	9:30 a. m.					
Jonesboro	do	9:30 a. m.					
Nettleton	do	9:30 a. m.					
McGehee	do	9:30 a. m.					
McArthur	do	9:30 a. m.			1	8	$111,000.
Newport	do	9:30 a. m.					
Pine Bluff	do	9:30 a. m.					
Eudora	do	9:30 a. m.					
Gilbert	do	9:30 a. m.					
Paragould	do	9:30 a. m.					
Harrisburg	Mar. 24, 1913	Midnight					
Rumley	do	Midnight					
Powers	do	Midnight			3	13	$16,000.
Leslie	do	Midnight					
Murfreesboro	Apr. 27, 1914	4:15 p. m.			1	14	$25,000.
Bodcaw	Nov. 25, 1915	3:30 p. m.			1	14	$25,000.
Hot Springs	do	3:15 p. m.	100	SW	10	45	$300,000.
Almond	June 5, 1916				0	55	
Alvis	do				0	1	$500.
Baucum	do	5:30 p. m.		SW	1	5	$10,000.
Branner	do	4:30 p. m.		SW	4	1	
Barney	do	4 p. m.	150		1	4	$8,000.
Bee Branch	do			W	0	0	$5,000.
Blackville	do				1	Several.	
Cabot (near)	do	5:15 p. m.	1,000	SW	2	22	$15,000.
Carlisle	do	6:15 p. m.	900	SW	0	3	$1,200.
Carthage	do	5 p. m.	600	SW	0	9	
Cato	do	Day			0	5	Several houses.
Dalark	do	5 p. m.	5,000	SW	5	3	$5,000.
Dark Corner	do	6:30 p. m.			1	0	$10,000.
De Valls Bluff	do	6:30 p. m.		SW	0	0	
Greenland	do	2:30 p. m.	200	SW	1	16	$20,000.
Hamburg	do	Night			0	0	Several buildings.
Haynes	do	8 p. m.			4	40	$3,000.
Hazen	do	8:30 p. m.	1,000	SW	4	42	$6,000.
Heber Springs	do	4:15 p. m.	900	SW	20	150	$51,000.
Hot Springs	do	2:15 p. m.	600	SW	4	8	$25,000.
Imboden	do				1	Several.	House and crops.
Judsonia	do	5:30 p. m.	1,000	S	9	35	$20,000.
Little Rock	do	5 p. m.	500	SW	0	0	$5,000.
Marion	do	3 a. m.	1,000	SW	1	60	$5,000.
Morrillton	do	2:45 p. m.	2,000	SW	0	6	$22,000.
Nix	do	2 p. m.	5,000	SW	3	8	$5,000.
Ozark	do	1:30 p. m.	3,000	SW	1	1	$8,000.
Rector	do				5	2	
Sheridan	do	4:50 p. m.	3,000	SW	0	0	$2,000.
Stuttgart (near)	do				8	30	
St. Francis	do	8 p. m.	300	SW	5	6	$20,000.
Tuckerman	do	6:30 p. m.	300	SW	4	10	$50,000.
Vallier	do	Night			2	6	
Vandule	do	8 p. m.	1,000	SW	0	4	$6,000.
Lake Village	Dec. 20, 1916				0	1	Slight.
Leola to Des Arc	Dec. 26, 1916			SW	17		$100,000.
Clark, Dallas, and Grant Counties	Mar. 20, 1917			SW	6	Several.	Much damage.

TABLE 1.—*Tornadoes and tornado groups in Arkansas, 1879–1926*—Continued

Place	Date	Hour	Width	From—	Killed	Injured	Damage
			Feet				
Melwood	Mar. 31, 1917				1	Several.	Several homes.
Bellville	do				1		Do.
Manilla	May 27, 1917				6	5	$12,500.
Archillion	do						
Clear Lake	do				12	55	$43,000.
Cotton Wood Point	do						
Harrison	June 5, 1917	10:30 p. m.	225		0	0	$15,000.
Wrightsville to Olena	June 6, 1917	7 p. m.		NW	0	0	$73,000
Uniontown	June 7, 1917	Midnight			2		$4,000.
Newport	Apr. 3, 1918	5 p. m.	150	N	1	2	$2,500.
Kenset	Apr. 17, 1918		600	SW	0	10	$32,000.
Tupelo	do	1 a. m.	1,000	SW	0	5	$40,000.
Jonesboro	do	2 a. m.			0	0	Slight.
Keo	do	1:15 a. m.		SW	0	0	$3,000.
Amity	do	11:30 p. m.	2,000	W	0	10	$4,000.
Hope	Apr. 19, 1918			W	0	0	All crops.
Jelks	do	1:30 a. m.	1,000	SW	0	0	Slight.
McNeil	Apr. 27, 1918	10 p. m.	200	SW	0	0	$30,000.
Mulberry	May 10, 1918		1,000	SW			$8,000.
Altus	Mar. 16, 1919				0	9	$40,000.
Texarkana	Apr. 9, 1919				2	15	$10,000.
Saratoga	do				4	17	$25,300.
Ogden	do				2	15	$25,000.
Mickles to Piney	Apr. 18, 1920	Midnight	1,000	S	18	32	$100,000.
Oil Trough Bottom	Mar. 17, 1921				0	9	$10,000.
Mineola, Tex., to Mount Pisgah Settlement	do		2,000	SW	51		$1,175,000.
Yell and Pope Counties	Apr. 15, 1921	3:30 p. m.			5		$60,000.
Marche	do	8:45 p. m.					$12,500.
Wrightsville	do	8:45 p. m.			0	0	
Carlisle	Apr. 26, 1921	A. m.			0	0	$10,000.
Gould	do	A. m.			0	0	$10,000.
Oil Trough	Sept. 7, 1921	7 p. m.					Few houses.
Wicks	Nov. 17, 1921			W	8	39	
De Gray	do			SW	3		$20,000.
Clarkdale	Dec. 23, 1921	4 p. m.			6	15	$150,000.
Fallsville	Jan. 4, 1922	5 a. m.			3	2	$2,000.
Jacksonville	Jan. 7, 1922	9 a. m.			2		$5,000.
Arkansas City	Mar. 14, 1922				1	10	$15,000.
Kensett	do	A. m.			1	3	Slight.
Gethsemane	do	A. m.			6	8	$40,000.
Crossett	Mar. 20, 1922				0	0	$5,000.
Prescott	Mar. 30, 1922				0	0	Slight.
Little Rock	May 14, 1923	8 p. m.	500	SW	0	0	$70,000.
Sevier County	do			SW			Several thousand.
Jonesboro	June 27, 1923						$7,000.
Texarkana	Apr. 29, 1924	2:30 p. m.	300	SW	1	17	$25,000.
Washington County	May 28, 1924	6:30 p. m.			1		Hail, $100,000.
Fort Smith	do	Midnight		W	0	0	$25,000.
Hot Springs	Sept. 9, 1924	3 p. m.	200	SW	0	0	$100,000.
Beedeville	Dec. 7, 1924	4:50 p. m.			3	1	
Mulberry	Feb. 8, 1925				0	0	$20,000.
Bearden	Feb. 22, 1925				0	0	
Stuttgart	do				0	0	$15,000.
Blytheville	Nov. 26, 1925	2:30 p. m.	300	W	0	1	$4,000.
Marshall	Dec. 3, 1925	11 p. m.	150	SW	0	0	$3,500.
Lake Village	Feb. 24, 1926	8 p. m.	300	SW	5	15	$70,000.
Hiwasse	Apr. 23, 1926	5 p. m.	1,000	W	0	0	$3,000.
Fort Smith	May 23, 1926	7:30 p. m.		W	0	0	$25,000.
Wilson	Aug. 17, 1926		300	SW	2	11	
Aplin	Nov. 25, 1926			SW	0	3	$6,000.
Arkadelphia	do	6:30 p. m.		SW	0	3	$5,000.
Belleville	do	4:30 p. m.	300	SW	1	3	$20,000.
Buford	do				0	0	$20,000.
Choctaw	do		400	SW	3	2	$3,000.
Crow Mountain	do	5:15 p. m.	300	SW	1	7	$9,500.
Enders	do	6 p. m.	1,300	SW	1	6	$25,000.
Float Creek	do	P. m.			0	3	$10,000.
Gould	do	P. m.		SW	3	25	$20,000.
Greenbrier	do	5 p. m.		SW	0	0	None.
Do	do	6 p. m.	300	SW	0	1	$6,000.
Jacksonport	do	7:30 p. m.		SW	2	1	$9,000.
Heber Springs	do	6 p. m.	900	W-SW	20	75	$400,000.
Jessieville	do	7:30 p. m.			0	0	$5,000.
Macedonia	do				2	0	$15,000.
Mars Hill	do				1	0	$4,000.
Moscow	do	7:30 p. m.	300	SW	10	66	$20,000.
Old Hickory	do			W	1	0	$10,000.
Opello	do	5:15 p. m.	300	SW	5	7	$1,000.
Pearson	do	5:30 p. m.	1,200	SW	0	0	$9,000.
Perry	do	5:20 p. m.	200	SW	0	0	$2,500.
Portland	do	9:30 p. m.	300	SW	0	3	$3,000.
Quitman	do	5:15 p. m.	300	SW	0	0	$4,000.
St. Vincents	do				0	6	$8,000.
Sheridan, near	do		300	W-SW	1	5	$6,000.
Stafford	do	4:45 p. m.	300	SW	0	0	$5,500.
Wooster	do	6 p. m.	180	SW	0	0	$500.

TABLE 2.—*Monthly numbers of tornadoes in Arkansas, 1879 to 1926, with annual totals*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1879						1							1
1880				5									5
1881				1									1
1882													0
1883				2									2
1884					1		1						2
1885												1	1
1886													0
1887				1									1
1888													
1889													
1890													
1891													
1892											2		2
1893				2									2
1894										1			1
1895													0
1896										1			1
1897	2		3										5
1898	2						1						3
1899			1										1
1900													0
1901			5										5
1902													
1903													
1904													
1905													
1906													
1907													
1908											11		11
1909		3	13	9									25
1910													0
1911				2									2
1912		1		7				1					9
1913			19										19

TABLE 2.—*Monthly numbers of tornadoes in Arkansas, 1879 to 1926, with annual totals*—Continued

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1914				1									1
1915											2		2
1916						34						2	36
1917			3		4	3							10
1918				9	1								10
1919			1	3									4
1920				1									1
1921			1	6					1		2	1	11
1922	2		5										7
1923					2	1							3
1924				1	2				1			1	5
1925		3									1	1	5
1926		1	1	1				1			27		31
Total, 1879–1926	6	8	52	51	10	39	2	2	2	2	45	6	225
Total, 1908–1926	2	8	43	40	9	38	0	2	2	0	43	5	192

TABLE 3.—*Tornadoes in Arkansas and thunderstorms in Little Rock, 1908 to 1926*

	January	February	March	April	May	June	July	August	September	October	November	December
Number of tornadoes	2	8	43	40	9	38	0	2	2	0	43	5
Number of thunderstorms	26	47	89	134	123	176	179	154	93	44	41	25
Number of thunderstorms per tornado	13.0	5.9	2.1	3.4	13.7	4.6	----	77.0	46.5	----	1.0	5.6
Number of tornadoes per year	.11	.42	2.26	2.11	.47	2.00	0	.11	.11	0	2.26	.26

THE ROCKSPRINGS, TEXAS, TORNADO, APRIL 12, 1927

By J. H. JARBOE

[Weather Bureau, San Antonio, Tex., Apr. 20, 1927]

The low-pressure area that passed over Texas from April 11 to 13 caused an unusual number of destructive storms. Reports of lives lost and property damaged ranged from Del Rio to Texarkana, across a section of Texas seldom visited by tornadoes. The storm that occurred in Edwards and Real Counties on April 12, probably surpassed any previous record for this section of Texas.

This tornado first made its appearance on the Edwards Plateau, in the north-central portion of Edwards County, where it hit and practically destroyed the town of Rocksprings, taking a toll of 72 lives and injuring 200 more. About 235 residence and business buildings were destroyed, and property damage amounted to $1,230,000. But 12 houses were left standing and 6 of these were badly damaged.

The path of the tornado was first observed 3 miles north of Rocksprings. It moved southeastward, passing directly over the town, with a destructive diameter ranging from seven-eighths to 1⅛ miles in width, and about 8 miles long. It apparently jumped a hilly broken section of 25 miles and came to earth again in the south-central portion of Real County, passed near Leakey, where two people were killed and five injured. Here the path had narrowed to about one-fifth of a mile. Still moving southeastward, it next hit about 15 miles farther on, near Utopia, in the northeast portion of Uvalde County, where several buildings were blown down, but as far as known no one was seriously injured.

The path of this storm is about 65 miles in length. Just how many miles of this distance that the tornado was sweeping the ground will never be known. It passed over a very sparsely settled section of the State, most of its course being over rock hills with little vegetation. Houses are many miles apart and roads are few.

On April 19, an attempt was made to follow and map the path of the tornado from an airplane. In some ways this was disappointing. The first indications of the storm were seen 3 miles north of Rocksprings, where all trees were down; the path passed directly over the town, continued southeast for 5 miles beyond, approximately 8 miles in all, and then it was lost in rock hills.

The counterclockwise whirl of the wind-tossed débris made the air view one of unusual interest from a meteorological standpoint. Numbers of trees fell to the south and southeast, others fell to the east, and a few fell to the northeast and north. A rough estimate made while circling 2,500 feet above the tornado path indicated that 70 per cent fell to the south and southeast, 20 per cent fell to the east, and 10 per cent to the northeast and north. Débris from isolated houses on the south side of the town were strewn in a wide arc that curved counterclockwise. The town site of nearly a square mile revealed grim evidence of the terrific force of the tornado. Tangled wreckage was piled around the larger buildings, while acres of ground where lighter buildings stood were swept bare.

The path of the storm was followed with difficulty where trees were small and scattered, and it was entirely lost 5 miles southeast of Rocksprings, nor could any evidence be found that it came to earth between Rocksprings and the dry canyon of the Frio River. No attempt was made to map the storm path from Leakey to Utopia, but reliable information indicates that the path was 16 miles long and 200 to 300 yards wide.

There is some doubt about the time that the storm reached Leakey and Utopia. Some reported it to be near midnight. This would give the tornado a movement of less than 15 miles per hour, which is unlikely. Another tornado hit in Uvalde County about 60 miles south of Rocksprings the same night of the disaster; is reported to have traveled south and turned west, passing over an uninhabited section. It is possible that three separate tornadoes occurred.

Rocksprings is the county seat of Edwards County, with a population of about 1,200. It is an inland town, situated 39 miles from a railroad, upon a high, rolling plateau; the elevation is 2,450 feet. The surrounding country is devoted to livestock raising, wool, and mohair production.

No town was ever nearer completely wrecked than was Rocksprings. The tornado hit at 7:50 p. m. without warning. The day had been rather warm and a thunderstorm, apparently of moderate intensity, was hanging north of the town, promising a spring shower. Just before dark a fresh wind from the southeast dropped to a dead calm. The cloud to the north was noticeably red at this time and seemed to be swinging eastward. A few moments later scattered hail 2 inches or more in diameter began to fall, increasing in size to baseballs. The hail is described as being round but covered with bumps, and the noise of this hail falling on the houses was heard a half mile away, which was the first warning many people had of the approach of a severe storm.

People in different parts of the town describe the wind as blowing from different directions. Some state that for two minutes before their houses collapsed the wind was from the northeast or north and increasing in strength. Others say that from a dead calm a west wind hit their house, lifting it from the ground. The destructive wind lasted about one and one-half minutes, but wreckage continued to move about for around 10 minutes or more. No rain fell until after the passage of the tornado and no measurement of the amount was made, although a heavy electrical storm followed, with probably an inch of rain. Surrounding districts received 2 to 3 inches.

People 50 to 60 miles away observed a red, some say a yellowish, cloud over Rocksprings. No funnel-shaped cloud was seen from the town. Those that happened to be looking at the sky to the north just before the tornado came state that the cloud seemed to dip suddenly to the ground near the town. Hail was falling at this time and a great roar and grinding noise was heard by all. A minute and a half later but 12 buildings were standing. Numbers of buildings entirely disappeared even to the foundations, leaving no trace of lumber or contents. Many injured people were further bruised and cut by heavy hail that continued to fall after the passage of the tornado, as no shelter was available. Concrete and stone failed to withstand the terrific fury of the storm and heavily constructed buildings were left gaping ruins. The courthouse and post office partly escaped the tornado, but caught fire and burned.

Because of the unusually large diameter of the tornado to an observer viewing the débris from any one ground position it would seem that the damage was the result of a straight blow, but in reality the counterclockwise rotary motion of the tornado was definitely indicated by the fall of the buildings and chimneys. Blocks of houses in the northern portion of the town fell to the south and southeast, while across the central portion they went to the east, and in the southern part of the town houses fell toward the northeast, with one going northwest.

A cement church appeared to have been wrecked by expansion of air. The walls were cracked or broken about 12 feet above the floor and bulged outward 1 to 3 feet, although still standing.

OBSERVING A TORNADO'S LIFE

By T. G. SHIPMAN

[Weather Bureau, Fort Smith, Ark., May 18, 1927]

The morning weather map of April 12, 1927, showed a shallow low-pressure area apparently with a western center in Arizona and an eastern one in Kansas. Pressure in Arizona was about 29.68 inches and in Kansas 29.64 inches. Northward of this depression was a moderately strong HIGH. Warm, sultry weather prevailed over the regions under the influence of the LOW, while it was much colder northward. A well-defined wind-shift line appeared over western Kansas. The evening map showed much the same weather conditions, with the depression center farther south. General weather conditions were sluggish, local conditions warm and sultry, and the tornado which occurred at Fort Smith on this date had a very slow progressive motion and only moderate intensity.

The tornado developed within one-quarter to one-half mile of the station, with the edge of the storm very near it, and was observed through its short existence by both employees on duty. Only weak instrumental effects were noted at the station, which is unusual for such close proximity to a tornado. Pressure showed a drop of 0.04 inch and a rise of 0.06 inch, about the average for a thunderstorm. The temperature drop was small, and the wind attained a maximum velocity of 24 miles an hour, with an extreme velocity of only 34 miles an hour. No wind velocity records were made within the path of the tornado, but estimates from effects would place it at about 100 miles an hour.

The sky was cloudy all day. Cloud and surface records showed several air strata with varying directions. At 7:00 a. m. five-tenths alto-stratus clouds from the west, five-tenths alto-cumulus clouds from the south, and a surface wind from the east were recorded. At 12:18 p. m. ten-tenths strato-cumulus clouds from the southwest and a surface wind from the southeast were recorded. At 4:20 p. m., just after the tornado, four-tenths alto-stratus clouds with undetermined direction, five-tenths strato-cumulus clouds from the west, one-tenth cumulo-nimbus clouds from the west, with a surface wind from the northwest were recorded. At 7:00 p. m. seven-tenths strato-cumulus from the southwest, three-tenths cumulo-nimbus from the southwest, and a surface wind from the northeast were recorded. All observations were made by the same employee and personal equations may be disregarded. Every wind direction was recorded in some air strata during the day either by cloud observation or instrumental records. Upper-air currents were southerly to westerly as far as cloud observations showed, and surface currents easterly. This territory has considerable local atmospheric stratification.[1] Six tornados have been recorded at Fort Smith beginning with 1879.

Tornado signs appeared at about 4:00 p. m., central time. Heavy rains were noted west of the station in Oklahoma just before 4:00 p. m. Seemingly very low-

[1] MONTHLY WEATHER REVIEW, December, 1925, 53: 535-536.

lying scud was noted through office windows at 4:03 p. m., just east of the station. Clouds moved in opposite parallel paths, one from the north and one from the south. *These opposite parallel currents were so arranged that if any right-hand deflection took place a dimuntion of air pressure would develop between them.* After a short interval, a vortex apparently formed without a funnel cloud. Under the vortex débris rose, appearing like cinders or light trash ascending to the clouds. After observing this for about one minute both station employees ascended to the roof of the Federal building for better observing. Open sky was noted to the north, east, and south near the horizon, but the horizon was obscured to the west. The break in the clouds near the horizon afforded an excellent opportunity for observation of the formation of the small but energetic tornado whirl, and the light from the break probably diminished the dark hue of the clouds as they seemed more slate-colored than tornado clouds are usually described. Light thunder and lightning were recorded near the beginning of the storm.

The converging and turmoil of the clouds were observed from the roof of the building by Weather Bureau employees for about one minute. The movement was east-southeast. A short, heavy rain and light hail lasted about one minute at this time. After the ending of the rain, skies began to clear on the western horizon and darken on the eastern.

The first actual destruction, as witnessed by Weather Bureau employees, took place at 4:04 p. m. Houses were reported damaged a little earlier at 814 Wheeler Avenue, near Emma Street, at 4:02 or 4:03 p. m. Unofficial reports from persons in the open indicated a cloud at this time, but it is hard to determine whether they saw a tornado cloud or the turbulent cloud activity, but the latter is thought to be the case. At 4:04 p. m. the débris shot upward under the vortex in a cloud of dust. The ascending wreckage had the appearance of a great explosion or sparks from a great fire and was distributed in horizontal strata until drawn into the vortex. Watching the successive ascending phenomena gave one the impression that the seat of energy was above the earth and the ground features were the result of suction. These formations appeared three successive times, without a tornado cloud being formed. Each successive formation seemed to accumulate strength and to produce worse effects than the preceding one. Effects were very similar to blasting operations. The time interval between the first and second was about 1 minute and between the second and third about 30 seconds.

The fourth ascending formation was marked by a descending cloud resembling a misshapen cornucopia which failed to reach the ground, and was accompanied by a larger amount of dust and wreckage. This dissipated after about one minute and re-formed. The fifth formation, or second funnel cloud, appeared as two large bells top to top with a thin ropelike pendant connecting them. This was the most distinct, sharply defined, and beautiful of the entire series and lasted only a few seconds. The sixth formation and third funnel cloud formed in a few seconds. The ascending débris reached the dimensions of a giant explosion. The formation widened, accompanied by rain and a cloud of débris, and moved slowly to the northeast, finally disappearing. The greatest destruction occurred with the sixth ascending phenomenon. Airplane observations afterwards showed that the path narrowed before the storm dissipated, which feature could not be observed from the roof of the building. Débris lay in practically straight lines parallel to the path of the storm for the last quarter of mile of the path. Sounds, as heard at some distance from the storm, resembled the hum of a motor, but they were quite harsh and loud near the storm area.

An imposing display of towering cumulus and cumulonimbus clouds was observed in the direction in which the tornado disappeared, resembling cumulus formed over great fires. The pictures of the tornado at Austin, Tex., May 2, 1922,[2] would almost fit the tornado at Fort Smith, April 12, 1927.

The path of the tornado was not more than 4 miles long and about 150 yards wide. The tornado varied in strength and direction throughout its path. The path ran generally from the southwest to the northeast and lay about one-half mile east of the tornado of January 12, 1898.[3] Two persons were killed and 13 injured seriously enough to require hospital attention. The damage was estimated at $100,000. The strength of the storm was only moderate for a tornado, with only a few examples of total wreckage. Houses were unroofed, awnings torn down, fences moved, trees uprooted, garages destroyed, and light buildings moved from foundations. Absence of marked tornado freaks was also noted.

Few freak conditions, often reported from tornado districts, could be found. A child was taken up by the wind, carried for 3 miles, and let down scratched but not injured. A woman, evidently killed in the tornado area, was found 7 miles away. A number of automobile tires were carried a mile and dropped. A heavy timber, 14 by 14 inches and 12 feet long, was carried half a mile south of town. Hundreds of chickens disappeared and engines were stripped from automobiles. There was no way even to estimate the excessive wind velocity, but the photographs [not reproduced here] make it certain that it was hundreds of miles per hour.

[2] Monthly Weather Review, May, 1922, 50: 252-253.
[3] Monthly Weather Review, January, 1898, 26: 18-19.

VARIABLE FEATURES OF BAROMETRIC DEPRESSIONS AND ANTICYCLONES AS A BASIS FOR SEASONAL FORECASTING

By N. A. Hessling

[In charge of daily forecasting service of the Argentine Meteorological Office]

For a country like Argentina, with *extensive* rather than *intensive* farming, seasonal forecasts would undoubtedly be of much more practical use than daily forecasts of the weather. For this reason, for some time, I have been trying to find a basis for such forecasts. Correlations between different meteorological elements in various parts, along the lines followed by Walker in India, have been found, but they are generally too vague to be of any practical value, at least by themselves, and the same may be said of relations with sun spots, solar radiation, etc.

Since I have been engaged in daily forecasting of the weather, I have been struck by the remarkable tendency of certain types of pressure distribution and weather to repeat themselves in some years or seasons, while in other years the opposite types are more frequent. Some types bring dry weather and others wet weather, and the prevalence of each type determines the dryness or wetness

of the season. The persistence of certain types for long periods indicates that their cause must be some general condition, probably connected with the general circulation of the atmosphere, and this suggests that by studying these types we might find a basis for seasonal forecasting.

With the object of confirming this hypothesis, computations were made of the mean latitude of barometric depressions and anticyclones, the frequency of certain typical tracks in different seasons, and other characteristic features that could be correlated with the rainfall and temperature of the same and following seasons. The results have really been better than I expected, the rainfall of autumn, winter, and spring giving correlation coefficients of 80 per cent and over when compared with some features of the depressions or anticyclones of the preceding season.

The results have been published in detail in the Monthly Bulletin of the Argentine Meteorological Office (in Spanish), but as it is thought that they may be of a more general interest, a short abstract is herewith given.

The mean latitude of centers of barometric depressions (when first observed) in winter and summer seems to give a fairly close representation of the rainfall to be expected in the following spring and autumn, respectively. In Tables 1 and 2 the corresponding values are given, the rainfall at Buenos Aires having been chosen. The correlation is larger than this at some stations and smaller at others.

TABLE 1

	Mean latitude of depressions in summer (December to February)	Total rainfall at Buenos Aires in autumn (March to May)
		Millimeters
1913–14	31.8	597
1914–15	29.9	244
1915–16	29.3	174
1916–17	30.3	227
1917–18	29.9	140
1918–19	30.7	386
1919–20	29.9	282
1920–21	30.4	326
1921–22	30.4	243
1922–23	29.1	260
1923–24	29.3	184
1924–25	30.3	341
1925–26	30.7	347

Correlation coefficient, 0.84.

TABLE 2

	Mean latitude of depressions in winter (June to August)	Total rainfall at Buenos Aires in spring (September to November)
		Millimeters
1913	30.0	463
1914	29.4	414
1915	29.0	238
1916	24.2	133
1917	26.0	98
1918	28.5	211
1919	28.6	355
1920	27.0	341
1921	27.4	202
1922	24.9	193
1923	25.9	203
1924	26.0	165
1925	29.3	377
1926	27.6	189

Correlation coefficient, 0.79.

For the winter rains the behavior of anticyclones seems to be a better guide than that of depressions. The anticyclones observed in the Argentine are always quite formed when crossing the borders, the depressions, on the other hand, in most cases forming within the country, except those crossing the southernmost portion, which have not been taken into account in this study.

By their point of origin the anticyclones that cross Argentina may be divided into two principal classes, those that come from the Pacific and apparently are offshoots of the permanent South Pacific anticyclone, and those that come from the Antarctic regions and which probably are offshoots of the great anticyclone that is supposed to lie over the South Pole.

The most frequent tracks of anticyclones are in a northeasterly direction, crossing Argentina into Uruguay or Brazil. In certain years the tracks show a more northerly trend, the centers passing latitude 35° west of the sixty-fifth meridian, after which they either continue farther north or turn to the east. Some anticyclones pass with their centers along the Atlantic coast, this type being most frequent in spring and summer.

As will be seen from Table 3, the amount of rainfall in the winter months may be foreseen approximately in the autumn, taking into account either the number of anticyclones appearing south of 45° latitude, the mean latitude of all anticyclones when crossing the western border, the frequency of anticyclones having a northerly and oceanic track, or those having the normal northeasterly track. The correlation coefficient is positive with the first three values and negative with the fourth.

TABLE 3.—*Relation between positions of highs in the autumn (March–May) and the rainfall of the succeeding winter in Buenos Aires*

Year	A Frequency of HIGH centers south of latitude 45°	B Mean latitude of all HIGHS when entering Republic	C Frequency of HIGHS with northerly and with oceanic tracks	D Frequency of HIGHS with northeasterly tracks	E Total rainfall in Buenos Aires in winter (June to August)
					Millimeters
1913	1	39.0	2	11	140
1914	4	41.0	8	2	400
1915	0	38.9	2	14	50
1916	0	35.3	0	16	11
1917	4	40.6	4	6	206
1918	3	39.1	1	14	75
1919	3	39.7	6	7	211
1920	0	37.7	1	13	48
1921	1	38.7	4	13	113
1922	7	41.8	12	5	540
1923	3	39.4	8	6	307
1924	2	38.0	8	13	76
1925	5	41.5	9	7	94
1926	3	40.0	11	7	188

Correlation coefficient:
A–E 0.76
B–E .70
C–E .67
D–E –.84

It will be noticed that the winter rainfall agrees fairly well with what might be expected according to the trend of the anticyclones in the autumn, except in the year 1925, when the rainfall was less than would have been expected. It is noteworthy, however, that although the rainfall was below normal that winter, the humidity and cloudiness was among the highest in this series of 14 years, so it could not really be classified as a dry winter.

For the summer rainfall no very marked correlation has yet been found, the mean latitude of depressions in spring giving a slight negative correlation. The largest correlation found for the summer rainfall is with the mean

latitude of anticyclones in the previous winter, this giving 0.54. This lack of result for the summer may be due to the fact that the rainfall in this season often occurs in heavy thundershowers and the variations are more irregular than in other seasons.

The temperature does not show such high correlations as the rainfall for any season, but the winter temperature compared with the trend of the anticyclones in autumn gives a coefficient of 0.71. Some results obtained lately, and which will be published in the near future, indicate that the difficulty to obtain a large correlation with the temperature is due to the complication set up by the effect of cloudiness on temperature.

It is probable that the shifting south of the barometric depressions in some seasons and of anticyclones in other seasons and the trend of the latter to move north or over the ocean are really indications of one and the same phenomenon, which may be an increased energy of the equatorial air currents as opposed to the polar air currents.

It is noteworthy that these trends of depressions and anticyclones do not show any marked correlation with the barometric pressure variations in Argentina, though it is possible they might show it with the pressure of the equatorial region of Brazil.

Further researches are being conducted along these lines, and it is hoped they may give not only practical results for seasonal forecasting, but may also throw light on some problems of the general circulation of the atmosphere and the cause of abnormalities of certain seasons.

NOTES AND ABSTRACTS

THE MASS EXCHANGE IN THE FREE AIR AND RELATED PHENOMENA [1]

The study of atmospheric turbulence has nowadays grown to a very live branch of meteorology, with numerous applications in different fields. In this development W. Schmidt, in Vienna, has played one of the foremost parts, being one of the creators of the fundamental conception "Austausch" (exchange) upon which the theory of atmospheric turbulence tests. Schmidt has made it his task to prove the fertility of this conception in a number of problems also outside pure meteorology. It is therefore most gratifying that a monograph from his hand has appeared which in a popular way treats the question of the turbulent exchange of mass in the atmosphere as well as a number of its geophysical and geographical botanical consequences.

The chief effect of the exchange of mass through a fixed horizontal unit surface in the atmosphere is, as well known, that any element the vertical distribution of which is not uniform will be subject to a vertical transport or diffusion. This transport or flow upward per square centimeter and second is equal to the product of a coefficient, A, in the rate of decrease upward of the element under consideration. The first of these factors, the "Austausch," depends solely upon the rate of mass exchange and is independent of the element discussed. The second factor depends only upon the element discussed and is independent of the mass exchange.

The above expression for the diffusion can now be applied to any property of the air that remains constant during adiabatic compression and expansion; for instance, horizontal momentum, potential (not ordinary) temperature, water vapor content (in absence of condensation), electric charge, content of dust, condensation nuclei, seed, and pollen. The theory can, of course, also be applied to turbulence in the sea. Schmidt treats in his book the effect of turbulent mass exchange on all these elements and on a number of others not mentioned here.

In the section devoted to the vertical temperature distribution, Schmidt has subjected the diurnal variation of temperature at different levels to a very illuminating study. It is shown how the actually observed oscillations are composed of two terms, one depending upon the diurnal variation of absorption and emission of radiation at that level, while the second term represents the temperature variation at the surface which is propagated upward with decreasing velocity and amplitude.

The same section also discusses the difference between continental and maritime climate. It is shown that the usual explanation of the difference between these two climatic types, which is based upon the difference between the thermal capacities of water and soil, is very unsatisfactory. The specific heat per unit volume of water is only about twice that of the soil; if the soil and the water otherwise behaved in the same way, this difference would produce a ratio of the amplitudes of the diurnal temperature variations equal to $\sqrt{2}:1$, while the actually observed ratio is many times larger. The true explanation lies in the *turbulence* of the sea, which rapidly carries the heat accumulated at the water surface downward to deeper strata. In the ground there is no such turbulence; only the extremely small molecular conduction of heat is active, at a very slow rate carrying accumulated heat downward, but leaving the greater part of it to be reradiated to the lowest atmospheric layers.

It is impossible in a short review to mention all the questions which lend themselves advantageously to a treatment by the Austausch method. Schmidt makes, after Richardson, comparisons between the upward transport of water vapor and the precipitation; these two quantities must become equal when means are formed over the globe and for a long period (for instance a year).

There is in Schmidt's book one application of the theory of turbulent diffusion, which as far as I can judge should be of the greatest value to botanists and geographers; namely, the spread of pollen and seed by wind and turbulence. Using a mean wind velocity of 6 meters per second, an "Austausch" value of 20 units, and taking into account variations in velocity of free fall for different kinds of seed and pollen, Schmidt is able to compute for each a "mean dispersion limit." He arrives at the following values:

	Kilometers
Spores of *Lycoperdon*	460, 000
Pollen of *Pinus silvestris*	40
Seed of *Taraxacum officinale*	10
Seed of *Betula verrucosa*	1. 6

The mean dispersion limit is defined as the distance from the plant beyond which less than one one-hundredth of the seed or pollen will reach.

Other chapters in the book are devoted to questions relating to atmospheric electricity, vertical wind distribution, dissipation of energy in the atmosphere, etc. The book is pleasingly written and deserves all attention from meteorologists and others interested in atmospheric phenomena.—*C. G. Rossby.*

[1] Der Massenaustausch in freier Luft und verwandte Erscheinungen, von Dr. Wilhelm Schmidt, Hamburg 1925. (Probleme der Kosmischen Physik, VII.)

THE VARIATION OF METEOROLOGICAL ELEMENTS AT ST. HELENA AND AT SOME OTHER PLACES IN THE ATLANTIC REGION[1]

[Author's abstract]

It is shown that since 1892 pressure, wind velocity, and temperature (mean daily maximum and minimum) at St. Helena have been subject to marked secular variations, pressure, and maximum temperature rising, while since 1903 wind velocity has decreased. These variations are interrelated in such a way that they are probably real and not instrumental, and it is shown that the most likely explanation is the gradual northward movement of the South Atlantic anticyclone. The variations are further examined by the calculation of "partial" correlation coefficients. The investigation is then extended to the North Atlantic; in Sierra Leone pressure has increased slowly while temperature has decreased slowly and rainfall has decreased by an average of 2.4 inches a year. These variations also are investigated by "partial" correlation. In the Azores and Madeira pressure has increased more rapidly than in Sierra Leone, and it is shown that the variations are probably accounted for by an increase in the intensity of the North Atlantic anticyclone and in the strength of the northeast trade wind. Various meteorological changes in Europe, North America, and the Arctic, which may be related to the above variations, are also discussed.—*C. E. P. Brooks.*

THE DISTRIBUTION OF ARCTIC ICE

[Reprinted from Nature, April 23, 1927]

The Danish Meteorological Office has published its report on "The State of Ice in Arctic Seas, 1926." Conditions in nearly all Arctic seas were unusually favorable. In the Barents Sea the distribution was about normal, but in August open water reached almost to Franz Josef Land. Eastern Spitzbergen, however, does not appear to have been free from ice, but the west coast was entirely clear during the summer months. The Kara Sea was congested in the south, but vessels got through by using Matochkin Strait. In the Greenland sea and Denmark Strait conditions were very favorable, and the east coast of Greenland was relatively easy of access. The coasts of Iceland were open throughout the year. On the Newfoundland Banks the amount of ice was below the normal. Ports on the west coast of Greenland were more accessible than usual, and in Hudson Strait there was less ice than has been noted during the past six years.

Bering Sea was open so early as the end of June, and there were long stretches of open water along the coasts of Siberia and Alaska during the summer. This is at least the fourth year in which ice conditions generally have been subnormal and in which no exceptional drift has been reported from any part of Arctic Seas.

* * * * *

THE SECOND EDITION OF DEFANT'S "WETTER UND WETTERVORHERSAGE"

In the more than eight years since the author brought out the first edition, the forward strides of meteorology have been so vigorous that much of the book, especially the first part, "Das Wetter," was rapidly becoming obsolete. In the second (1926) edition (issued by Franz Deuticke, Leipsig and Vienna), the student will recognize the profound influence which the Bjerknes school has exerted upon meteorological thought in Europe. One finds extensive revision, retaining, however, a careful liaison between the older ideas and the newer. A fine feature of the book is the abundance of small but very clear diagrams and charts; especially pleasing are the synoptic charts on blue bases. A wealth of footnote references to literature takes the place of loading the text with a discussion of researches which seem to the author to be of subordinate importance.—*B. M. V.*

METEOROLOGICAL SUMMARY FOR SOUTHERN SOUTH AMERICA, MARCH, 1927

By J. B. NAVARRETE, Director

[Observatorio del Salto, Santiago, Chile]

The month of March, 1927, was characterized by a weak atmospheric circulation in the southern region. The first five days were in general dry, while in the second five days a preceptible increase in rainfall was observed.

The most important depressions which crossed the far south were as follows:

That of the 3d–4th, which caused rain as far north as Arauco. The heaviest precipitations were those of 53 mm. at Puerto Montt and 37 mm. at Valdivia.

That of the 20th–21st; it rained as far north as Arauco. The heaviest rainfalls were 22 mm. at Puerto and 14 mm. at Valdivia.

That of the 27th–29th which caused heavy winds and rainfall over the greater part of the southern region. Maxima were 41 mm. at Puerto Montt, and 26 mm. at Valdivia.

The most important anticyclonic centers were as follows: That of the 5th to 18th, which was notable for its prolonged stability; those of the 22d–26th, and of the 30th–31st. All these periods were characterized by generally fine and cool weather.—*Transl. B. M. V.*

METEOROLOGICAL SUMMARY FOR BRAZIL, MARCH, 1927

By J. DE SAMPAIO FERRAZ, Director

[Directoria de Meteorologia, Rio de Janeiro]

As observed in daily charts, the general circulation at lower levels was a little more active this month. Five anticyclones crossed the continent in the usual paths. Depressions were generally shallow and not persistent, affecting very little the central region of the country. In the south, contrasts of pressure were more frequent. The highs referred to above were not vigorous. Rain distribution was very irregular in the north and central regions of Brazil, and on the average below normal; in the southern part precipitations were much more abundant, with an average well above normal.

Weather was generally favorable to crops, especially to cotton, coffee, and sugar.

[1] Geophysical Memoirs No. 33—Air Ministry, Meteorological Office, Vol. IV, No. 3

BIBLIOGRAPHY

C. FITZHUGH TALMAN, Meteorologist in Charge of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Abbot, C. G.
Group of solar changes. Washington. 1927. 16 p. figs. 24½ cm. (Smith. misc. coll. v. 80, no. 2.) (Pub. 2916.)

Ångström, Anders.
Recording nocturnal radiation. Stockholm. 1927. 12 p. illus. plate. 31½ cm. (Medd. Statens met.-hydrog. anstalt. Bd. 3, N:o. 12.)

Brazil. Directoria de meteorologia.
Atlas de nuvens. n. p. 1924. 8 plates. 34½ cm.

Ferraz de Carvalho, Anselmo.
Clima de Coimbra . . . Resumo das observações feitas no Observatório meteorológico da Universidade de Coimbra desde 1866 . . . Lisboa. 1922. 73,114 p. figs. plates. 32½ cm.

Hartnack, Wilhelm.
Wanderdünen Pommerns, ihre Form und Entstehung. Greifswald. 1925. vi, 112 p. illus. plate. 24½ cm.

Jaeger, Fritz.
Forschungen über das diluviale Klima in Mexico. Gotha. 1926. viii, 64 p. plates (part fold.) 28 cm. (Petermanns Mitteilungen, Ergänzungsheft Nr. 190.)

Mallory, Walter Hampton.
. . . China: land of famine . . . New York. 1926. xvi, 199 p. incl. front. illus. maps. 26 cm. (Amer. geographical soc. Spec. pub. no. 6.) [Includes discussion of rainfall, drought, floods, etc.]

Martonne, Emm. de.
Une nouvelle fonction climatologique: l'indice d'aridité. 10 p. figs. plate. 27½ cm. (Extr.: La Météorologie, oct., 1926.)

Mawson, Douglas.
Records of the aurora polaris. Sydney. 1925. 191 p. figs. plates. 30½ cm. (Australasian Antarctic exped. 1911–1.4 Sci. rep. ser. B. v. 2. Terr. mag. & related observ. pt. 1.)

Niblack, A. P.
Ocean currents in relation to oceanography, marine biology, meteorology and hydrography. Monaco. 1927. 43 p. 27½ cm. (Internat. hydrog. bur. Spec. pub. no. 19, March, 1927.)

Sen, Sachindra Nath.
On the design of the Kew pattern barometer. London. 1925. p. 203–225. plates. diagrs. 31 cm. (Great Brit. met. off. Geophys. mem. no. 27 (v. 3, no. 7.)

Shaw, William Napier.
Manual of meteorology. v. 1. Cambridge. 1926. xx, 339 p. illus. plates. ports. diagrs. (part fold.) 27 cm.

Smith, Wesley L.
How I fly at night. p. 228–233. illus. 29 cm. (Journ. soc. automotive engin., N. Y. v. 19, Sept., 1926.)

Stifel, Richard E.
Every cloud has a foggy lining. p. 65–66. illus. 29½ cm. (Hygeia. Feb., 1927. v. 5, no. 2. (Chicago: Amer. med. assoc.)

Tucker, W. M.
Cloud types. p. 79–82. 22½ cm. (Proc. Indiana acad. sci.)

Wiese, W.
Polareis und atmosphärische Schwankungen. p. 273–299. diagr. 24½ cm. (Geografiska annaler, H. 3 och 4, 1924.)

Young, H. C., & May, Curtis.
Timing of apple scab sprays. 28 p. illus. 23 cm. (Ohio agric. exper. sta. Bull. no. 403, March, 1927.)

RECENT PAPERS BEARING ON METEOROLOGY

The following titles have been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

Annalen der Hydrographie und maritimen Meteoroligie. Berlin. 55. Jahrgang. 1927.

Baur, Franz. Wert und Verwertung von Beziehungsgleichungen zur Voraussage von Mittelwerten der Wetterelemente für grössere Zeitabschnitte. p. 36–41. (Februar.)

Petersen, P. Die Eisverhältnisse des Winters 1925/26 in den ausserdeutschen europäischen Gewässern. p. 18–21. (Januar.) p. 41–49. (Februar.)

Wegener, Kurt. Die Plata-Stürme vom 10.–11. Juli 1923 und 10.–11. Januar 1925. p. 33–36. (Februar.)

Astrophysical journal. Chicago. v. 64. March 1927.

Lindemann, F. A. Note on the physical theory of meteors. p. 117–123.

Aviation. New York. v. 22. 1927.

McAdie, Alexander. The fliers' aspects of aerography. Electric storms present certain hazards. Few cases of planes being struck. One on record proved inconsequential. p. 571–573. (March 21.)

Andrus, C. G. Airways aerological work. How the Weather bureau stations function to provide air mail pilots with accurate weather information. p. 778–779. (April 18.)

Beiträge zur Geophysik. Leipzig. 16. Band, 1./2. Heft. 1927.

Kartschagin, W., & Sweschnikowa, M. Über den Tagesgang der Sonnenstrahlung und der vom Zenith kommenden zerstreuten Himmelsstrahlung. p. 54–65.

Milch, W. Über die Extinktion der langwelligen und der kurzwelligen Sonnenstrahlung in der Atmosphäre der Erde. p. 66–107.

British astronomical association. Journal. London. v. 37. March, 1927.

Kuiper, P. Feenstra. The green ray. p. 231–235.

Ecology. Brooklyn. v. 8. April, 1927.

Shantz, H. L. Drought resistance and soil moisture. p. 145–157.

Stantchinsky, V. V. Some climatic limits in the extension of birds in eastern Europe. p. 232–237.

Engineering news-record. New York. v. 98. April 28, 1927.

Notes on heavy rainfall April 15–16 at New Orleans and vicinity. p. 697.

France. Académie des sciences. Comptes rendus. Paris. t. 184. 1927.

Lakhovsky, Georges. Influence des rayonnements astraux sur l'oscillation des cellules vivantes. p. 907. (4 avril.)

Mémery, Henri. L'influence des radiations astrales sur les vins. p. 908–909. (4 avril.)

Moreux, Th. Sur l'activité solaire et certains phénomènes de végétation. p. 1090–1091. (2 mai.)

Franklin institute. Journal. Philadelphia. v. 203. May, 1927.

Barnes, Howard T. Thermit and icebergs. p. 611–634.

General electric review. Schenectady. v. 30. 1927.

Peek, F. W., Jr. The protection of oil tanks and reservoirs against lightning. p. 117. (Feb.) [Extract from art. in Journ. A. I. E. E.]

Lee, Everett S., & Foust, C. M. Measurement of surge voltages on transmission lines due to lightning. p. 135–145. (March.)

Mitsuda, R. Lightning survey in Japan. p. 124–128. (March.)

Geografiska annaler. Stockholm. Årg. 9. H. 1–2. 1927.

Ahlmann, Hans W:son. Physico-geographical researches in the Horung massif, Jotunheim. p. 9–66.

Ångström, Anders. Probleme und Aufgaben der meteorologischen Strahlungsforschung. p. 144–148.

Bäckman, Allan. L'influence de l'altitude et de la position géographique sur la température de l'air dans la région sud-ouest de la Suède. p. 133–141.

Exner, Felix M. Über Dünen und Sandwellen. p. 81–99.

Johansson, Osc. V. Die Temperaturänderung mit der Höhe an der Erdoberfläche in Skandinavien. p. 109–132.

Hemel en dampkring. Den Haag. 25 jaargang. Mei 1927.

Schoute, C. Loodsballon- en stralingswaarnemingen gedurende een reis met het S. S. Gelria naar Buenos Aires. p. 158–166.

Ibérica. Tortosa. Año 14. 7 mayo 1927.

L., A. F. El huracán de 1926 en la Habana. p. 300–302.

Imperial academy. Proceedings. Tokyo. v. 3. February, 1927.
Kobayasi, Tatuo. On the mechanism of cyclones and anticyclones. p. 72–75.
Nagaoka, Hantaro. On clicks and grinders in atmospherics. p. 64–67.

International institute of agriculture. International review of the science and practice of agriculture. Rome. New series. v. 4. October–December, 1926.
Sampaio Ferraz, J. de. Causes of drought in north-eastern Brazil. p. 916–917. [Abstract.]
Sanson, J. Transmission of meteorological-agricultural data by means of radiotelephony. p. 921–922. [Abstract.]

Marine observer. London. v. 4. 1927.
Barnes, Howard T. Experimenting with icebergs. p. 93–98. (May.)
Williams, C. H. Making simple weather charts at sea. p. 111–112. (June.)

Matériaux pour l'étude des calamités. Genève. Année 3. Octobre-decembre 1926.
Flammarion, Gabrielle Camille. "Orages dans le soleil, tempêtes sur la terre." p. 274–275. [Abstract from L'Illustration.]
Michotte, Félicien. Étude sur les incendies de forêts. p. 281. [Abstract. Author believes many forest fires are due to some unknown action of atmospheric electricity.]
Mougin, P. Le danger des glaciers et des inondations en Savoie. II. Le danger des eaux. p. 206–232.
Renner, George T., Jr. The Sudan: a tropical famine area. p. 187–205.
Sampaio Ferraz, I. de. Causes probables des sécheresses dans le nord-est de Brésil. p. 279–280. [Abstract.]

Meteorological magazine. London. v. 62. April, 1927.
Bonancina, L. C. W. The west of England blizzard in March, 1891. p. 69–70.
Douglas, C. K. M. Bergen daily charts. p. 61–63.
G., J. Cloudburst cavities. p. 66–68.
Hudson, J. C. "The circulation of air in Stevenson screens as shown by corrosion." p. 53–57.
Whipple, F. J. W. The detonating meteor of February 25th, 1927. p. 57–61.
Whipple, F. J. W. Rime and associated phenomena. p. 68–69.

Météorologie. Paris, n. s. t. 3. Mars 1927.
Baldit, Albert. Sur deux particularités des nuages: Les nappes nuageuses angulaires et les nuages d'ombre. p. 97–104.
Bidault de l'Isle, G. La "pluie de sang" du 30 octobre 1926. p. 122–124.
Charcot, J., & Idrac, P. Sur un phénomène de dépression atmosphérique produit sous le vent d'un obstacle élevé. p. 117.
Instruction sur le montage et l'emploi du mano-détendeur pour le gonflement des ballons avec l'hydrogène en tubes. p. 114–116.
Mercanton, Paul. Le contrôle chronométrique des enregistreurs météorologiques. p. 118–120.
Papillon, J. Soupape automatique de gonflement de ballons-sondes de 0m,75 de diamètre modèle Office national météorologique. p. 104–113.
Roger, E. Le cercle de Bishop à Paris. p. 120–121. [Observed Nov. 14, 1926.]

Meteorologische Zeitschrift. Braunschweig. Band 44. April 1927.
Fabian, Hans. Die Verdunstungsmessungen auf der Scheitniger Schleuseninsel bei Breslau. p. 142–146.
Fischer, Karl. Bemerkungen zu Hans Fabian: "Die Verdunstungsmessungen auf der Scheitniger Schleuseninsel bei Breslau." p. 146–148.
Götz, P. Das Strahlungsklima von Arosa. p. 138–142. [Abstract.]
Pollak, Leo Wenzel. Periodogramme hochfrequenter Schwankungen meteorologischer Elemente. p. 121–130.
Steiner, L. Zu Franz Baurs Grundlagen einer Vierteljahrstemperaturvorhersage für Deutschland. p. 148–151.
Stoye, Karl. Kernzahl, relative Feuchtigkeit und Sicht. p. 151–153.
Száva-Kováts, J. Witterungsperioden im Winter. p. 131–137.

Nature. London. v. 119. 1927.
Owens, J. S. Haze. p. 561–562. (April 16.)
Gold, E. Water vapour in the atmosphere. The constitution of fog and cloud. p. 654–655. (April 30.)

Nature. Paris. 1927.
Roger, E. Des particularités remarquables de la température dans la région de Paris, d'après les travaux des météorogistes E. Renou et L. Besson. p. 370–371. (15 avril.)
Carle, G. Observations faites à l'occasion du cyclone qui dévasta la ville de Tamatave le 3 mars 1927. p. 426. (1 mai.)

Naturwissenschaften. Berlin. 15. Jahrgang. 15. April 1927.
Corlin, Axel. Der kosmische Ursprung der Höhenstrahlung. p. 356–357.

Paris. Services techniques d'hygiène. Annales. t. 7. 1926.
Besson, Louis. La température à Paris d'après cinquante années d'observations. p. 1–47.

Physical review. Minneapolis. v. 29. May, 1927.
Hurlburt, E. O. The absorption of radio waves in the upper atmosphere. p. 706–716.

Physical society. Proceedings. London. v. 39. April 15, 1927.
Deodhar, G. B. Electricity of dust clouds. p. 243–249.

Physikalische Zeitschrift. Leipzig. 28. Jahrgang. 1927.
Benndorf, H. Die Erhaltung der Erdladung durch den Blitzstrom. p. 260–261. (No. 7.)
Tichanowsky, I. I. Die Bestimmung des optischen Anisotropiekoeffizienten der Luftmoleküle durch Messungen der Himmelspolarisation. p. 252–260. (No. 7.)
Wigand, A. Erdladung, Blitzstrom und Niederschlagsstrom. p. 261–263. (No. 7.)
Holtzmann, M., & Keller, L. Ein Apparat zur Messung der atmosphärischen Turbulenz. p. 304–308. (No. 8.)
Nölke, Fr. Zur Erklärung der anormalen Schallfortpflanzung. p. 302–304. (No. 8.)

Popular astronomy. Northfield, Minn. v. 35. May, 1927.
Wylie, Charles Clayton. The solar cycle in temperature and in crops. p. 253–256.

Prussia. Meteorologisches Institut. Bericht über die Tätigkeit des Preussischen meteorologischen Instituts im Jahre 1926. Berlin. 1927.
Knoch, K. Über die unperiodischen Schwankungen der Temperatur im atlantischen Stillengürtel. p. 69–84.
König, W. Über die Niederschläge der Vb-Depressionen. p. 84–93.
Marten, W. Über die beiden absoluten pyrheliometrischen Skalen Ångström und Abbot. (Nach Vergleichsmessungen in den Jahren 1919–1926.) p. 59–69.
Schubert, D. O. v. Ein typisches Beispiel für den Zusammenhang hoher und niederer Druckschwankungen. p. 113–133.
Süring, R. Nachruf auf Walter Budig. p. 39–42.
Wagemann, H. Über die Erwärmung kalter Luft zwischen dem amerikanischen Festlande und den Bermudas-Inseln. p. 134–142.

Revue de géographie alpine. Grenoble. t. 14. fascicule 4.
Bénévent, E. Documents sur le climat des Alpes françaises. Étude critique. p. 681–764.

Revue générale des sciences. Paris. 37. année. 1927.
Adam, Michel. Une nouvelle hypothèse scientifique. L'influence des taches solaires sur la vie et la santé. p. 177–179.
Rouch, J. L'électricité atmosphérique dans les régions polaires. p. 242–244.

Revue d'optique théorique et instrumentale. Paris. 6 année. Février 1927.
Peyre, Jean. Mesure de la brillance du ciel diurne. Répartition de la lumière sur la voûte céleste. p. 73–80.

Royal society of London. Proceedings. London. series A. v. 114. April, 1927.
Dobson, G. M. B., Harrison, D. N., & Lawrence, J. Measurements of the amount of ozone in the earth's atmosphere and its relation to other geophysical conditions. Part II. p. 521–541.
Simpson, C. G. The mechanism of a thunderstorm. p. 376–401.

Science. New York. v. 65. 1927.
Curie, M., Lorentz, H. A., & Einstein, A. The establishment of an international bureau of meteorology. p. 415–417. (April 29.)
Nutting, P. G. Humidity and chronometry. p. 471. (May 13.)

Science news-letter. Washington, D. C. v. 11. April 23, 1927.
Talman, C[harles] F[itzhugh]. Most tornadoes do little damage. p. 261.

Scientific American. New York. v. 83. 1927.

Dunlap, Orrin E., Jr. Does static come from the sun? Strange "messages" may tell the secrets of fading and other radio mysteries. p. 318–319. (May.)

Wood, B. Francis. Weather map by radio. p. 411–412. (June.)

Tycos-Rochester. Rochester, N. Y. v. 17. April, 1927.

Blair, Thomas Arthur. Weather cycles. p. 61–62.

The father of the American weather map. [Abbe, Cleveland.] p. 63. [With portrait.]

Laskowski, B. R. Ground temperatures vs. roof temperatures. p. 68–70.

Maddox, William J. Tracking hurricanes to their lair. p. 45–47.

Measurements in cloudland. p. 65.

Moran, C. "John Smith vs. Jack Frost." p. 53–55.

The mystery of ice-fringes. p. 73.

Pearson, S. K., Jr. "Hurricanes existed when Columbus discovered America and will develop in future." p. 49–50.

Professor William Ferrel. p. 64. [With portrait.]

Simpson, A. G. The lumber industry discovers relative humidity. p. 74–75.

Simson, A. Gael. Static as barometer to forest fires. p. 60–61.

"Snow-break" in woods and forests. p. 73.

The table cloth of Table mountain. p. 66.

Talman, C[harles] F[itzhugh]. Picturing the weather day by day. The remarkable government machinery that produces the daily weather map. p. 51–52; 77.

The tower of the winds. p. 66.

Van Cleef, Eugene. A hurricane near the Grand Banks. p. 48; 77.

White, William J., Jr. The new wonders of our sun. Exiles on lonely desert mountain to study vast power plant of the sky. p. 56–59. [Repr. from Popular science monthly.]

U. S. Hydrographic office. Pilot chart of the north Pacific ocean. June, 1927.

Hurd, Willis Edwin. Tropical storms of the eastern north Pacific ocean.

Wetter. Berlin. 44. Jahrgang. 1927.

Fischer, Rudolf. Sehr milde und sehr kalte November seit 1826 in Frankfurt a. M. p. 39–41. (Februar.)

Kassner, C. Babylonische und assyrische Wetterregeln. p. 47–48. (Februar.)

Kassner, C. Schneebeseitigung auf dem Fall River Hochpass in Colorado. p. 46–47. (Februar.) [Trans. from Bull. Amer. met. soc.]

Myrbach, Otto. Der Temperaturverlauf zu Wien im Winter 1925/26 in Zusammenhang mit Sonnenfleckenkulminationen und Mondphase. p. 31–37. (Februar); p. 55–56. (Marz.); p. 74–78. (April.)

Voigts, Heinrich. Meteorologie und Wetterkunde in den physikalischen Lehrbüchern für höhere Schulen. p. 25–30. (Februar.); p. 49–55. (März.)

Beck, F. X. Zur Praxis des Flugwetterzettels. p. 72. (März.)

Gockel, A. Vom Wettersinn der Wetterkranken. p. 69–70. (März.)

Holtzhey, R. Die Bildung einer Gegensonne. p. 70. (März)

Holtzhey, R. Das Schwirren von Telegraphendrähten. p. 70–71. (März.)

Naegler, W. Die wärmste und kälteste Gegend Sachsens. "Sächsisches Nizza"—"Sächsisches Sibirien." p. 68–69. (März.)

Diesner, P. Weitere Bemerkungen über den Geltungsbereich klimatologischer Stationen. p. 93–95. (April.)

Der Frühsommer 1926. p. 78–85. (April.)

Gleichzeitiges Auftreten von Gewitter und Nordlicht am 8. September 1926. p. 85–89. (April.)

Noth, H. H. v. Ficker: Maskierte Kälteeinbrüche. p. 91–93. (April.)

M. Alfred de Quervain. p. 73–75. (April.) [Obituary.]

SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING APRIL, 1927

By HERBERT H. KIMBALL, Solar Radiation Investigations

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1924, 52:42, January, 1925, 53:29, and July 1925, 53:318.

From Table 1 it is seen that solar radiation intensities averaged above the April normals at all three stations.

Table 2 shows a deficiency in the total solar radiation received on a horizontal surface from the sun and sky at the three stations for which normals have been determined, due to unusual cloudy conditions.

Skylight polarization measurements made at Madison on three days give a mean of 62 per cent, with a maximum of 65 per cent on the 3d. These are close to normal values for April at Madison. At Washington, measurements made on four days give a mean of 54 per cent, with a maximum of 60 per cent on the 11th. These are slightly below the corresponding averages for April at Washington.

TABLE 1.—*Solar radiation intensities during April, 1927*

Washington, D. C.

[Gram-calories per minute per square centimeter of normal surface]

Date	Sun's zenith distance										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Apr. 6	6.27						1.02	0.68	0.57		6.50
Apr. 7	3.63	0.73	0.86	1.05	1.13	1.48	1.15				4.37
Apr. 11	2.62	0.86	1.01	1.11	1.32	1.52	1.29	1.09	1.00	0.86	2.49
Apr. 12	4.75	0.85	0.89	1.02	1.18	1.43					4.17
Apr. 14	2.87			1.14	1.30	1.44	1.25	1.08			3.63
Apr. 20	14.10					1.29	0.87				12.68
Apr. 23	3.00	0.77	0.92	1.06	1.24	1.39					3.30
Apr. 25	4.37	0.67	0.80	0.95	1.16	1.42					3.99
Apr. 28	3.81	0.66		0.98	1.19	1.49	1.10	0.91			4.57
Means		0.76	0.90	1.04	1.22	1.43	1.13	0.94	(0.78)	(0.86)	
Departures		+0.05	+0.14	+0.15	+0.14	+0.07	+0.03	+0.03	+0.03	+0.24	

Madison, Wis.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
Apr. 5	5.16				1.30	1.53	1.29				5.56
Apr. 6	5.79					1.47	1.30				5.16
Apr. 20	3.15				1.29						3.15
Apr. 23	3.15			1.14	1.26	1.47					2.06
Apr. 27	6.27				1.11	1.31					6.50
Apr. 30	4.57				1.22	1.45	1.18				5.16
Means				(1.14)	1.24	1.45	1.26				
Departures				+0.05	+0.02	+0.03	+0.04				

Lincoln, Nebr.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
Apr. 4	8.18					1.55	1.38	1.23	1.06	0.92	7.29
Apr. 6	5.36				1.13						5.16
Apr. 17	7.57	0.76	0.88	1.04	1.22	1.45					7.04
Apr. 18	8.48			0.90	1.06						13.13
Apr. 19	11.38						1.32	1.15	1.00		5.56
Apr. 21	2.87		1.05	1.20	1.37	1.57					2.26
Apr. 22	3.30	0.86	0.93	1.08	1.31	1.54					3.00
Apr. 25	6.27		0.91	1.06	1.24	1.43					8.18
Apr. 26	7.87			0.91	1.23		1.21				6.27
Apr. 27	5.79		0.60	0.83	1.05						6.27
Apr. 29	7.87					1.47	1.16	0.93	0.79	0.69	5.56
Means		(0.81)	0.87	1.00	1.20	1.50	1.27	1.10	0.95	(0.80)	
Departures		+0.07	+0.04	+0.02	−0.01	+0.05	+0.09	+0.12	+0.11	+0.09	

[1] Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation						Average daily departure from normal		
	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Washington	Madison	Lincoln
1927									
Apr. 2	259	315	344	383	283	497	−122	−67	−73
Apr. 9	430	373	155	284	423	467	+19	−28	−264
Apr. 16	402	326	438	271	278	536	−25	−78	−10
Apr. 23	404	378	485	333	373	648	−24	−51	+17
Deficiency since first of year on Apr. 29							−4,830	−2,975	−5,698

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. Edwin T. Pollock, Superintendent U. S. Naval Observatory]

[Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson observatories]

Date	Eastern standard civil time		Heliographic		Area [1]	
			Longitude	Latitude	Spot	Group
1927	h.	m.	°	°		
Mar. 9 (Yerkes)	12	10	+6.9	−14.5	73	
Mar. 30 (Yerkes)	12	40	−62.3	+16.0	97	
Apr. 3 (Naval Observatory)	14	3	−56.0	+14.0	93	
			−43.0	+13.5		710
			−38.0	−24.0	62	
			−10.5	−15.0		20
			−8.5	+17.5	46	
			−4.0	−13.0		40
			+54.0	+15.5		62
			+61.5	−22.5		340
Apr. 4 (Mount Wilson)	14	25	−41.0	+14.0	97	
			−41.0	+10.0	1	
			−27.5	+12.5		724
			−25.0	−24.5	20	
			−10.0	−16.0		2
			+6.0	+16.0	71	
			+7.0	−8.0		6
			+7.0	−14.0		6
			+12.0	+22.0		10
			+46.0	−14.0		4
			+70.0	+14.5	3	
			+73.0	−23.0		473
Apr. 5 (Yerkes)	9	56	−80.0	−15.5	485	
			−30.5	+13.5	75	
			−24.0	+15.0	75	
			−19.0	+13.0	100	
			−15.0	+11.0	120	
			+16.0	+16.0	95	
			+25.0	+22.0	50	
			+79.0	−29.0	480	
Apr. 6 (Naval Observatory)	11	46	−82.0	−17.0		247
			−60.0	−13.5		278
			−16.0	+14.5	62	
			−5.0	+14.0		463
			+30.0	+16.5	42	
			+37.0	+22.0		62
			+71.0	−13.5		123
Apr. 7 (Naval Observatory)	11	47	−68.0	−17.0		278
			−55.0	−14.0		278
			+7.0	+12.5		463
			+42.5	+16.5	31	
			+50.0	+22.0		46
			+85.0	−15.0	123	
Apr. 10 (Naval Observatory)	12	7	−79.0	+30.0	216	
			−78.0	−7.0		247
			−45.0	−22.5		46
			−38.5	+13.5		123
			−26.0	−17.5		278
			−14.0	−14.0		185
			+34.5	+13.5		31
			+51.0	+12.5		432
			+72.0	+5.0		62
Apr. 11 (Naval Observatory)	11	51	−80.0	+11.0		309
			−72.0	+33.0		741
			−69.0	−7.0		46
			−68.0	−14.5		62
			−60.5	−7.5		93
			−29.0	−21.5		46
			−25.0	+14.0		108
			−20.0	−18.5	9	
			−10.5	−18.0		278
			−0.5	−13.0		139
			+63.0	+13.0		370
Apr. 12 (Naval Observatory)	11	46	−67.0	+11.5		216
			−58.0	+32.5		216
			−57.0	−5.5	25	
			−53.0	−15.0		139
			−47.5	−7.5		31
			−15.0	−21.5		31
			−12.5	+13.5		77
			−0.5	−18.0		370
			+12.5	−13.0		139
			+79.0	+13.0		278
Apr. 14 (Naval Observatory)	11	49	−49.5	+18.0		31
			−42.0	+11.0		77
			−30.5	+32.5		123
			−27.5	−15.0		185
			+11.5	−21.0		15
			+12.5	+14.5		123
			+21.5	+14.5		31
			+24.0	−19.0		432
			+39.5	−13.0		46

[1] Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere.

Positions and areas of sun spots—Continued

Date	Eastern standard civil time	Heliographic Longitude	Heliographic Latitude	Area Spot	Area Group
	h. m.	°	°		
Apr. 15 (Naval Observatory)	11 42	−37.0	+18.0	31	
		−28.0	+11.0		62
		−27.0	−12.0		154
		−13.5	+30.0	40	
		−13.5	−15.0		216
		+25.0	−11.0	25	
		+27.0	+14.5		123
		+34.5	+14.5	18	
		+37.0	−19.0		340
		+52.5	−12.5		77
April 16 (Naval Observatory)	11 41	−21.0	+21.0		19
		−17.5	+13.0		15
		−13.0	−10.0		247
		−10.0	+12.0		46
		−5.0	+36.5	31	
		−2.0	−14.0		185
		+2.0	+31.0	46	
		+37.0	−23.5	19	
		+43.0	+12.5		216
		+49.5	−20.0		370
		+62.0	−16.0		62
Apr. 17 (Naval Observatory)	11 42	+1.0	−10.5		370
		+11.0	+30.5	31	
		+13.0	−14.0		139
		+54.0	−21.0		46
		+54.0	+14.0		185
		+63.0	−17.0		154
		+78.0	−11.5	62	
Apr. 18 (Naval Observatory)	11 44	−73.5	+9.5	108	
		+14.5	−10.5		370
		+24.0	+30.5	25	
		+28.0	−14.0		139
		+67.0	+15.0		123
		+79.0	−17.0		185
Apr. 19 (Mount Wilson)	12 40	−87.0	−20.0	118	
		−57.0	+9.0		116
		−50.0	−18.0		8
		+27.0	−12.0		545
		+39.0	+30.0	18	
		+45.0	−15.0		205
		+68.0	+26.0	32	
		+86.0	+13.0	80	
Apr. 20 (Naval Observatory)	11 49	−73.5	−19.5	62	
		−45.0	+9.5		46
		+34.5	−10.5	123	

Positions and arears of sun spots—Continued

Date	Eastern standard civil time	Heliographic Longitude	Heliographic Latitude	Area Spot	Area Group
	h. m.	°	°		
Apr. 20 (Naval Observatory)	11 49	+44.0	−10.5	170	
		+49.5	+30.0	15	
		+57.0	−13.5		123
Apr. 21 (Naval Observatory)	11 40	−60.0	−20.0	123	
		−32.0	+9.5	31	
		−22.0	+24.5		31
		+48.0	−10.5	139	
		+58.5	−10.5	231	
		+70.0	−13.5		123
Apr. 22 (Mount Wilson)	18 30	−78.0	−15.0		20
		−43.5	−20.0	55	
		−15.0	+8.0	28	
		−5.0	+24.0		88
		+70.0	−12.0		377
Apr. 23 (Naval Observatory)	11 53	−58.5	−15.0		93
		−34.0	−20.0	58	
		−6.5	+9.5	25	
		+3.0	+24.5		93
		+74.0	−10.0	154	
		+85.0	−10.0	247	
Apr. 24 (Naval Observatory)	12 28	−46.0	−17.0		108
		−20.0	−20.0	62	
		+16.5	+24.0		108
Apr. 25 (Naval Observatory)	11 47	−76.5	+5.0	216	
		−33.0	−17.5		201
		−7.0	−20.0	46	
		+29.0	+24.0		93
Apr. 26 (Yerkes)	18 16	−59.0	+4.0	75	
		−41.5	+19.0		100
		−16.0	−16.5		150
		+9.5	−20.5	50	
		+19.0	−17.5	25	
		+45.0	+25.0	50	
		+72.0	−8.0	75	
Apr. 27 (Naval Observatory)	12 15	−49.5	+4.5	170	
		−32.0	+21.0		93
		−6.0	−16.5		185
		+19.5	−20.0	31	
		+56.5	+24.5	31	
Apr. 28 (Naval Observatory)	11 47	−35.5	+4.5	154	
		−17.5	+21.0		93
		+3.5	−17.5		93
		+9.5	−12.5		93
		+31.5	−20.0	31	

AEROLOGICAL OBSERVATIONS

By L. T. SAMUELS

The month was characterized by free-air temperatures which were above normal, particularly at the higher levels. (See Table 1.) The departures were greatest from 2,000 meters to 3,000 meters at the southern stations. As might be expected under such conditions, the relative humidity was mostly below normal and the vapor-pressure departures were in general of the same sign as those for temperature.

A general excess of southerly winds occurred in the resultants for the month at all stations. (See Table 2.) The deviations from the normal were most pronounced at Royal Center and Ellendale. At the former station the northerly resultants contained a marked easterly component up to 1,250 meters instead of the more usual westerly; at Ellendale the resultant direction was southwesterly as compared to the normal northwesterly. In this connection it is interesting to find that the total precipitation at both of these stations exceeded all previous records for April since their establishment in 1918.

That a high lapse rate is not always a precursor of precipitation is shown in the kite records of Due West for April 26. A second flight was made in the afternoon at this station on account of the rapid fall in pressure. Both flights were made on the northern side of a tongue of high pressure extending inland over the South Atlantic and Gulf States. The wind direction changed but little with altitude, being westerly to west-southwesterly at the surface and west-northwesterly above 3,000 meters. The following lapse rates prevailed during the day.

Time	M. S. L. (m.)	°C./100 m.
7:56 to 9:37 a. m.	217 to 1,757	0.62
9:37 to 10:12 a. m.	217 to 1,757	.98
1:30 to 2:12 p. m.	217 to 2,061	1.10
4:12 to 4:50 p. m.	217 to 2,163	1.06

These superadiabatic lapse rates resulted in strong convection, but owing to the low relative humidity, which for the most part was below 50 per cent, no cumulus clouds developed, the sky remaining clear throughout the day.

The heights to which the temperatures successively increased under the influence of air emanating from the rear of a slowly moving high pressure area are shown in the following table taken from the kite records of Broken Arrow for the 25th, 26th, and 27th.

M. S. L. (m.)	25th (°C.)	26th (°C.)	27th (°C.)
233	7.5	10.3	17.0
500	8.2	13.0	17.0
1,000	5.0	17.8	22.6
1,500	2.7	14.1	19.8
2,000	3.3	10.5	16.9
2,500	1.5	6.8	13.0
3,000	−0.2		9.0

All of these records were obtained between the hours of 6 and 9 a. m. and therefore are comparable as regards the ordinary diurnal temperature changes. In every case the relative humidity was low in the upper levels as it usually is in a high-pressure area. It will be seen that the temperature at 3,000 meters on the 27th was higher than that which occurred in the lower levels on the 25th.

Temperature inversions are nearly always accompanied by a drop in relative humidity. However, occasionally the reverse relationship is found. Such a case occurred at Due West on the 8th, when that station was situated between a high-pressure area to the northeast and a LOW to the southwest. The data in the following table are taken from the beginning and end of the kite flight.

	M. S. L. (m.)	° C.	° C./100 m.	Relative humidity (per cent)	Wind direction
7:15 a. m.	217	13.0		62	E.
8:00 a. m.	639	8.4	1.09	75	ENE.
8:06 a. m.	878	11.4	−1.26	100	ESE.
11:04 a. m.	217	12.5		50	ENE.
10:50 a. m.	810	4.6	1.23	62	ENE.
10:44 a. m.	1,131	12.2	−2.37	100	SE.

A superadiabatic lapse rate prevailed from the ground to about 500 meters, above which level there was a strong inversion of temperature wherein the relative humidity increased to the saturation point. It will be noted in the table that in both cases the wind direction in the inversion layer contained a southerly component. The shallowness of the stratus cloud layer and the low relative humidity above it, however, prevented precipitation before the following morning, by which time this region was entirely under the influence of the LOW.

Easterly winds at exceptionally high altitudes prevailed over Spokane from the 9th to 14th, when that station was situated between a HIGH to the north and a LOW to the south. During this period winds from an easterly direction were observed to 9,000 meters.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during April, 1927*

TEMPERATURE (°C.)

Altitude (m.) m. s. l.	Broken Arrow, Okla. (233 m.) Mean	Departure from 9-yr. mean	Due West, S. C. (217 m.) Mean	Departure from 7-yr. mean	Ellendale, N. Dak. (444 m.) Mean	Departure from 10-yr. mean	Groesbeck, Tex. (141 m.) Mean	Departure from 9-yr. mean	Royal Center, Ind. (225 m.) Mean	Departure from 9-yr. mean	*Washington, D. C. (7 m.) mean
Surface	16.9	+1.3	16.9	−0.3	5.9	−0.1	19.8	+1.6	9.1	−1.3	15.4
250	16.8	+1.3	16.5	−0.4			19.0	+1.5	8.9	−1.2	13.1
500	15.5	+1.5	14.0	−0.6	5.5	−0.2	17.5	+1.6	6.9	−1.0	11.0
750	14.5	+1.9	12.9	−0.1	4.0	−0.3	16.4	+1.5	6.0	−0.6	9.3
1,000	13.8	+2.2	12.3	+0.5	3.2	0.0	16.2	+2.0	6.3	+0.7	8.1
1,250	13.2	+2.6	11.0	+0.5	2.5	+0.4	15.7	+2.2	5.6	+1.1	7.0
1,500	12.1	+2.6	9.8	+0.7	1.5	+0.6	15.4	+2.5	4.6	+1.2	5.7
2,000	9.7	+2.6	6.4	+0.3	−0.8	+0.8	13.8	+2.9	2.2	+1.1	3.7
2,500	6.6	+2.4	3.8	+0.3	−3.4	+0.9	11.4	+3.1	−0.3	+1.3	1.2
3,000	3.4	+2.3	1.0	+0.1	−6.2	+1.0	8.9	+3.4	−2.5	+1.7	−1.4
3,500	0.4	+2.4	−1.6	+0.1	−9.0	+1.2			−5.3	+1.5	
4,000	−2.9	+2.1	−5.4	−1.1	−11.7	+1.6			−7.3	+1.7	
4,500	−6.9	+1.1			−14.3	+1.9			−9.9	+1.7	
5,000	−9.8	+1.0							−13.2	+1.2	

RELATIVE HUMIDITY (%)

Altitude (m.) m. s. l.	Broken Arrow Mean	Departure	Due West Mean	Departure	Ellendale Mean	Departure	Groesbeck Mean	Departure	Royal Center Mean	Departure	Washington mean
Surface	70	+6	63	+3	69	+4	76	+4	71	+7	47
250	69	+5	63	+3			77	+5	71	+7	49
500	65	+2	67	+6	68	+4	77	+7	72	+8	50
750	61	−1	66	+5	65	+3	76	+9	70	+8	50
1,000	57	−3	68	+7	61	+1	68	+6	60	0	49
1,250	49	−8	70	+9	58	−1	61	+4	59	0	48
1,500	44	−11	67	+7	56	−2	47	−4	59	+1	50
2,000	38	−13	62	+4	56	0	37	−8	59	+2	49
2,500	37	−13	49	−4	57	+2	36	−8	45	−8	47
3,000	38	−12	51	+2	55	0	34	−9	38	−12	45
3,500	38	−13	40	−4	57	+1			38	−12	
4,000	40	−9	44	+1	67	+9			33	−14	
4,500	58	+7			70	+14			33	−11	
5,000	48	−4							31	−5	

VAPOR PRESSURE (mb.)

Altitude (m.) m. s. l.	Broken Arrow Mean	Departure	Due West Mean	Departure	Ellendale Mean	Departure	Groesbeck Mean	Departure	Royal Center Mean	Departure	Washington mean
Surface	13.97	+2.12	12.36	+0.33	6.40	+0.42	18.23	+2.71	8.62	+0.05	9.19
250	13.83	+2.09	12.11	+0.28			17.57	+2.75	8.50	+0.08	8.31
500	12.21	+1.81	10.90	+0.37	6.21	+0.39	15.93	+2.79	7.58	+0.29	7.43
750	10.79	+1.51	10.30	+0.68	5.42	+0.27	14.54	+2.76	6.84	+0.29	6.72
1,000	9.34	+1.00	10.20	+1.28	4.82	+0.15	12.78	+2.47	5.92	+0.02	6.16
1,250	7.75	+0.34	9.50	+1.39	4.36	+0.11	10.88	+2.01	5.46	+0.11	5.73
1,500	6.47	−0.15	8.08	+0.87	3.95	+0.12	8.09	+0.74	5.11	+0.22	5.58
2,000	4.85	−0.31	5.74	+0.17	3.27	+0.21	5.47	−0.09	4.27	+0.21	4.58
2,500	3.80	−0.30	3.42	−0.66	2.68	+0.20	4.63	+0.10	2.63	−0.47	3.42
3,000	3.10	−0.24	2.72	−0.39	2.11	+0.13	4.03	+0.30	1.70	−0.71	2.30
3,500	2.64	−0.13	1.39	−0.96	1.79	+0.17			1.30	−0.73	
4,000	2.23	+0.03	0.89	−0.96	1.85	+0.54			1.10	−0.64	
4,500	1.97	+0.08			1.59	+0.63			1.04	−0.40	
5,000	1.19	−0.40							0.98	−0.16	

* Naval Air Station.

TABLE 2.—*Free-air resultant winds (m. p. s.) during April, 1927*

Altitude (m.) m. s. l.	Broken Arrow, Okla. (233 m.) Mean Dir.	Mean Vel.	9-yr. mean Dir.	9-yr. mean Vel.	Due West, S. C. (217 m.) Mean Dir.	Mean Vel.	7-yr. mean Dir.	7-yr. mean Vel.	Ellendale, N. Dak. (444 m.) Mean Dir.	Mean Vel.	10-yr. mean Dir.	10-yr. mean Vel.
Surface	S. 21°W.	3.6	S. 8°W.	2.5	S. 44°W.	0.9	S. 75°W.	1.6	N. 14°E.	1.3	N. 16°W.	1.4
250	S. 22°W.	3.8	S. 8°W.	2.6	S. 44°W.	0.5	S. 75°W.	1.6				
500	S. 17°W.	5.3	S. 12°W.	4.0	S. 58°W.	1.9	S. 72°W.	2.6	N. 27°E.	1.3	N. 15°W.	1.5
750	S. 20°W.	6.3	S. 17°W.	4.9	S. 71°W.	3.1	S. 69°W.	3.4	S. 68°E.	0.6	N. 28°W.	1.0
1,000	S. 28°W.	6.1	S. 28°W.	5.4	S. 72°W.	5.4	S. 66°W.	4.3	S. 54°W.	1.0	N. 57°W.	1.3
1,250	S. 43°W.	5.6	S. 40°W.	5.5	S. 70°W.	9.1	S. 69°W.	6.0	S. 69°W.	1.5	N. 63°W.	2.0
1,500	S. 52°W.	6.8	S. 52°W.	6.1	S. 63°W.	10.3	S. 69°W.	7.3	S. 74°W.	1.9	N. 66°W.	2.5
2,000	S. 60°W.	8.0	S. 64°W.	7.2	S. 66°W.	10.6	S. 78°W.	8.4	S. 57°W.	2.8	N. 77°W.	3.2
2,500	S. 68°W.	7.6	S. 71°W.	7.8	S. 68°W.	10.8	S. 79°W.	10.0	S. 65°W.	4.0	N. 83°W.	4.9
3,000	S. 65°W.	8.0	S. 79°W.	7.8	S. 67°W.	11.8	S. 80°W.	10.8	S. 78°W.	5.7	N. 79°W.	6.7
3,500	S. 87°W.	8.4	S. 86°W.	9.8	S. 73°W.	13.2	W.	11.6	N. 85°W.	5.4	N. 78°W.	8.0
4,000	S. 56°W.	10.5	S. 80°W.	11.2	N. 87°W.	18.2	N. 82°W.	12.4	S. 70°W.	9.4	N. 73°W.	9.4
4,500	N. 68°W.	9.8	S. 88°W.	11.9					S. 64°W.	3.9	N. 61°W.	9.2
5,000	S. 68°W.	15.1	N. 84°W.	10.8								

Altitude (m.) m. s. l.	Groesbeck, Tex. (141 m.) Mean Dir.	Mean Vel.	9-yr. mean Dir.	9-yr. mean Vel.	Royal Center, Ind. (225 m.) Mean Dir.	Mean Vel.	9-yr. mean Dir.	9-yr. mean Vel.	Washington, D. C. (34 m.) Mean Dir.	Mean Vel.	7-yr. mean Dir.	7-yr. mean Vel.
Surface	S. 1°W.	4.4	S. 2°E.	2.4	S. 85°E.	2.4	S. 45°W.	1.4	N. 28°W.	1.9	N. 36°W.	1.5
250	S.	5.3	S. 2°E.	3.1	S. 77°E.	2.7	S. 45°W.	1.6	N. 28°W.	2.4	N. 62°W.	2.6
500	S. 1°W.	7.2	S. 2°E.	4.7	S. 51°E.	3.4	S. 44°W.	3.2	N. 28°W.	3.0	N. 69°W.	3.8
750	S. 7°W.	8.0	S. 10°W.	5.3	S. 40°E.	4.0	S. 52°W.	4.2	N. 38°W.	3.6	N. 61°W.	4.9
1,000	S. 15°W.	7.9	S. 20°W.	5.8	S. 27°E.	3.6	S. 58°W.	4.8	N. 38°W.	4.4	N. 61°W.	6.1
1,250	S. 25°W.	7.8	S. 30°W.	6.4	S. 8°E.	3.0	S. 70°W.	5.5				
1,500	S. 31°W.	8.1	S. 36°W.	6.9	S. 38°W.	2.8	S. 81°W.	6.6	N. 44°W.	6.4	N. 58°W.	7.5
2,000	S. 42°W.	6.6	S. 48°W.	7.7	S. 62°W.	4.7	S. 87°W.	7.9	N. 49°W.	8.3	N. 70°W.	8.5
2,500	S. 50°W.	8.5	S. 58°W.	8.3	S. 68°W.	6.3	N. 88°W.	8.6	N. 60°W.	11.9	N. 66°W.	10.4
3,000	S. 46°W.	10.2	S. 63°W.	10.1	S. 87°W.	13.6	N. 85°W.	10.4	N. 60°W.	15.6	N. 73°W.	11.2
3,500	S. 18°W.	11.8	S. 68°W.	10.0	S. 75°W.	13.2	S. 86°W.	12.0				
4,000					S. 77°W.	11.3	N. 87°W.	13.7				
4,500					N. 68°W.	14.7	N. 74°W.	14.6				
5,000					N. 56°W.	16.7	N. 73°W.	13.2				

GENERAL CONDITIONS

The single outstanding feature of the month, considering its subsequent effect, was the prolonged period of heavy rain over the central Mississippi Basin when the streams of the region were already at or near flood stage.

These rains were the direct cause of the unprecedented flood that is slowly passing down the lower reaches of the Mississippi and overland toward the Gulf of Mexico. The approximate area of land thus far inundated is 15,000 square miles.—*A. J. H.*

CYCLONES AND ANTICYCLONES

April showed a reduction in the number of barometric maxima and minima, 18 LOWS and 8 HIGHS being tracked. Rather sluggish conditions prevailed during the middle portion of the month; beginning with the 8th there was little relative change in the positions of the principal HIGHS and LOWS during six observation periods (three days) from western Europe westward to the middle Pacific Ocean. In this case the high-pressure area assumed a north-south position over the two oceans. As the polar air slowly drained southward, and pressure began to fall over high latitudes, a somewhat more normal movement began to develop.—*W. P. Day.*

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

By P. C. Day, in Charge of Division

PRESSURE AND WINDS

The marked features of the weather during April, 1927, were the persistence of moderate cyclonic conditions over the Southwest during the first two decades, and the abnormally heavy precipitation resulting therefrom as these moved to the eastward over the middle and lower Mississippi Valley, resulting in the most disastrous floods ever experienced in that river from Cairo southward and in many of its southern tributaries.

With the beginning of the month an important cyclone was central over the lower Missouri and middle Mississippi Valleys, and heavy rains had fallen during the preceding 24 hours over much of those and near-by areas. This storm lost importance rapidly and during the following 24 hours moved to the Middle Atlantic States with much decreased precipitation.

On the morning of the 4th pressure was low over the vicinity of eastern Kansas and during the following 24 hours the center moved to the Lake Superior region attended by considerable rain over the Mississippi and Ohio Valleys and Great Lakes, the rain area extending during the following day into the more eastern districts, due to the formation of a second storm that moved northward off the immediate Atlantic coast from the Carolinas to New England.

From about the 7th to 16th, inclusive, a period of 10 days, the atmospheric pressure continued low over the southern Plains and precipitation, excessive at times, was of almost daily occurrence over the immediate Mississippi Valley, particularly in Arkansas and Missouri, the eastern portions of Oklahoma, Kansas, and Nebraska, nearly the whole of Illinois, portions of Iowa, the western parts of Kentucky and Tennessee, northern Mississippi, and parts of Louisiana. The total falls on the 13th and 14th were particularly heavy over Arkansas and portions of near-by States, many stations reporting more than 5 inches in the 48-hour period and some as much as 10 inches.

After an interval of a day or so, in some sections scarcely so long, precipitation again began over much of the region mentioned above and continued with only short interruptions until the beginning of the third decade. During this period 24-hour amounts of precipitation, particularly in Arkansas, frequently exceeded 5 inches and in some cases they were above 10 inches.

After the 21st, high pressure and clear weather prevailed over the area where precipitation had persisted for so long and such cyclones as crossed the country were confined to more northerly courses, until near the end when another low-pressure area central over Missouri on the morning of the 29th moved southeasterly to the southern Appalachian region by the following morning attended by some heavy rains in the Ohio Valley and lighter amounts over near-by areas.

Despite the heavy rains in the middle and lower Mississippi Valley and some near-by areas, no cyclone giving extensive precipitation pursued a well-defined course over any considerable distance, nor were the heavy rains usually attended by important depressions of the barometer.

Anticyclones were confined mainly to the Great Lakes region and eastward to the Middle Atlantic States, New England, and the Canadian Maritime Provinces. In fact during the first half, high pressure was nearly continuous over these areas. At the beginning of the last decade anticyclonic conditions appeared over the Rocky Mountain region and, moving eastward, favored fair weather over the central valleys and southeastern districts until near the end of the month when low pressure again overspread the Central and Eastern States.

The distribution of monthly mean pressure is shown on Chart VI; departures from normal are shown on the inset on Chart I, and the change from the previous month on the inset on Chart II.

The important destructive winds of the month were mainly of the local character attending thunderstorms and usually covered but small areas at any time. They were confined as a rule to an area extending from Texas northeastward to the Great Lakes and Ohio Valley, and occurred most frequently about the 11th to 14th and again on the 18th to 21st.

A number of tornadoes occurred during the month, mostly in Texas, Arkansas, Oklahoma, and Illinois. The tornado that struck Rocksprings, Tex., on the evening of the 12th was the most severe of the month, resulting in the loss of 74 lives and damage to property exceeding $1,000,000. A storm of tornadic character passing northeastward from the vicinity of St. Louis, Mo., toward and over Springfield, Ill., and thence toward Chicago, on the afternoon of the 19th, caused the loss of 21 lives and property damage considerably in excess of $1,000,000. A list of these with others of less importance, together with the details of additional wind, hail, and other damaging storms of the month appears at the end of this section.

TEMPERATURE

The major portions of the first and second decades had moderate temperature changes with daily averages mainly above normal over the central valleys and south-

ern districts, and mostly below normal in those from the Rocky Mountains westward, the week ending the 19th being quite cool over that region.

About the end of the second decade high pressure entered the upper Missouri Valley and moving southward and eastward brought the most important temperature changes of the month and the lowest readings from the States of Washington and Oregon southeastward to the Gulf and South Atlantic coasts as far north as Virginia. In portions of the northern Plateau regions the minimum temperatures on the 19th and 20th were in numerous instances the lowest of record for so late in April, and much damage resulted to early fruits in the large commercial orchards of that region, including portions of Utah and Colorado. As this cold area moved eastward freezing temperatures extended into the northern and middle sections of the Gulf States and here, as well as to the northward, much damage to fruit and early vegetation resulted. About the same time unusually high temperature prevailed over the Northeastern States, the maximum temperatures over the coast districts of New England on the 20th being the highest ever reported in April. The average temperature for the week ending the 26th was below normal over all portions of the country save the Northeastern States and the far West.

With the passing eastward of the cold area referred to above, warmer weather followed, and the last few days of the month were moderately warm over most of the country, though cooler weather had overspread the lower Missouri and upper Mississippi Valleys, the Great Lakes region, and other near-by areas at the end of the month, with light frost in exposed localities.

The mean temperatures were above the normal for April over the greater part of the country, as has been the case, particularly in the central valley and Gulf States, during the preceding months of the year. The monthly temperatures were well above normal over all southern districts from New Mexico eastward, a few stations reporting means nearly or quite as high as had ever previously occurred in April. Temperatures were mainly slightly lower than normal over the Northeastern States and locally near Lake Michigan and in the far Northwest, likewise over the western Canadian Provinces, but they were higher to the eastward.

The highest temperatures were recorded about the 18th to 20th from the upper Mississippi Valley eastward and southeastward to New England and the Middle Atlantic States and locally in the Southeast, and from the 25th to 28th over the districts west of the Mississippi River and in a few States immediately to the eastward. The highest recorded was 108° in southern California and temperatures about 100° were observed locally in several States of the Southwest.

The lowest temperatures, as stated elsewhere, occurred mostly from the 19th to 23d, but over New England on the 2d and 3d, in portions of the Middle Atlantic States on the 10th and 11th, and over the Southwest from the 12th to 14th. The lowest reported was −18° in Wyoming with −16° in Colorado, −12° in California, and −10° in Idaho, all at exposed points in the mountains.

PRECIPITATION

The rains in the middle Mississippi Valley and near-by areas during the first two decades of April probably exceeded all previous records in that locality for total amounts of fall and length of period during which rain was of almost daily occurrence. In much of this area monthly amounts ranged from 10 to 15 inches, reaching more than 20 inches in some places, with plus departures ranging up to as much as 18 inches. Arkansas had a departure for the entire State of over 8 inches, Missouri had over 5 inches, and near-by areas of adjacent States had similar excesses. Over much of this area the precipitation during March had also been far in excess of the normal fall. As a result of these heavy rains the rivers of that section were in flood during the greater part of the month and some had the highest stages ever known.

Aside from the area referred to above, most of the central valleys, as well as the Middle Atlantic States, had precipitation above the normal. In the Southeastern States, however, the month was mainly quite dry, and similar conditions existed in New England and portions of the Lake region. In the far West precipitation was mainly less than usual, and there was a considerable deficiency over the central and west Gulf coast, save in the vicinity of New Orleans where a large excess was received. At points in Florida, the Carolinas, and New England the month was among the driest of record for April.

SNOWFALL

Some unusually heavy and long continued snows occurred in the northern Rocky Mountains during the first half of the second decade. This was most pronounced in Wyoming and near-by areas. At Cheyenne snow was of daily occurrence from the 10th to 15th, and similar conditions existed at numerous other points in that State, with total falls up to 3 feet or more. In central and southern Montana the depths ranged from 10 to 40 inches. In the Black Hills of South Dakota and western Nebraska the depths ranged up to 2 or 3 feet, with a small area in northwestern Nebraska of more than 4 feet, the greatest depth ever known in that locality. This period was without important wind movement and hence there was little drifting, and save for the unusual depth there was no great interference with traffic, as the weather continued mild and the snow soon disappeared.

Over the remaining mountain sections of the West the snowfall was mainly greater than usually occurs in April, particularly in the central and northern districts, and the outlook for water during the dry season is probably better than usual in the districts where water is mostly needed.

Over the more eastern districts some snow occurred over considerable areas, but the amounts were mainly small. The distribution is graphically shown as usual on Chart VII of this issue.

RELATIVE HUMIDITY

Generally speaking the average relative humidity was above the normal save from the upper Lakes to New England, locally over the Southeastern States, and mainly from the Rocky Mountains westward, though in this region there were areas with averages above the normal, this being particularly the case at points in Arizona and Nevada. At points in New England and New York the percentages of relative humidity were the least of record for April, and about the 11th and 12th the humidity was remarkably low over the coast districts, Providence, R. I., reporting 9 per cent at noon of the 12th and Boston 10 per cent on the same date, these probably being the lowest individual values ever observed at those stations. At points in the lower Missouri and middle Mississippi Valleys the percentages ranged from 5 per cent to 15 per cent above the normal.

SEVERE LOCAL STORMS, APRIL, 1927

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the annual report of the chief of bureau]

Place	Date	Time	Width of path, yards [1]	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Durham and Winston-Salem, N. C.	1	4 p. m.				High wind	Considerable damage to buildings and public utilities.	Charlotte Observer (N. C.).
Tarboro, N. C.	1	7:30 p. m.	550		$75,000	Tornado	Many large trees uprooted; some buildings unroofed or damaged; path 2 miles long.	Official, U. S. Weather Bureau.
Anderson, Greenville, Greenwood Laurens, Richland, and Darlington counties, S. C.	1		½ to 10 mi.		42,000	Series of thunderstorms with wind and hail.	Character of damage not reported	Do.
Kentucky (western)	1				50,040	Wind	Buildings and wire systems damaged	Do.
Poweshiek County, Iowa	4	10:30 a. m.	2,640			Hail	Damage principally to windows	Do.
Champaign, Christian, Greene, Jersey, McLean, Macon, Macoupin, Madison, and Montgomery Counties, Ill.	4	3 p. m.			165,000	Hail and wind	Greenhouses, roofs, and windows damaged by hail; much early fruit injured. Storms generally occurred in the afternoon.	Do.
Dallas, Tex. (vicinity of)	4	7:20 p. m.				Thunderstorm and hail.	Vegetables and fruit injured	Do.
St. Louis, Mo. (near)	4					Hail	Greenhouses and fruit considerably damaged	Do.
Thayer and Wheatfield, Ind.	4					do	Damage slight to considerable	Do.
Ashland and Seneca Counties, Ohio.	5					Wind and hail	Property damage reported	Do.
Sumter, S. C. (near)	5				5,000	Thunderstorm and wind.	Dwellings, barns, and plate-glass windows damaged.	Do.
Flint, Tex	6	2:30 a. m.	4 mi.			Heavy hail	Considerable damage to roofs and crops over path 20 miles long.	Do.
Grady County, Okla	6	5:45 p. m.	8 mi.		30,000	do	Heavy crop loss; some damage to other property.	Do.
Stevens County, Okla	6	8:30 p. m. and 10:30 p. m.	10 mi.		20,000	Two hailstorms	Heavy crop and considerable property damage over path 40 miles long.	Do.
Dougherty, Okla	6	9 p. m.				Heavy hail	Damage severe, crops practically a total loss	Do.
Fort Cobb, Okla. (7 miles southwest of).	6		880			Hail	Crop loss heavy; other property about $2,000. Path, 8 miles.	Do.
Tyler, Tex	6-7	10:45 p. m. 1 a. m.	7 mi.		95,000	Hail and rain	Severe damage to tomato and berry crops; much damage to farms and highways by washing.	Do.
Garvin County, Okla	6-7		5-15 mi.		100,000	Two hailstorms	Crop and property damage heavy	Do.
Dodge City, Kans. (15 miles west of).	7	7 p. m.				Tornado	Some buildings unroofed; a house turned around	Do.
Dodge City, Kans. (south of).	7					Thunderstorm and hail.	Roof damaged; wheat beaten	Do.
Geiger, Ala	8					Wind and hail	Character of damage not reported	Do.
Havre, Mont., and vicinity	8-9				5,000	Wind and snow	Several plate glass windows broken; numerous signs and chimneys blown over; wire systems damaged; some loss of livestock.	Do.
Springfield, Mo	9	2:20 a. m.			10,000	Severe thunderstorm.	Numerous basements flooded	Do.
Hollister, Mo	9					Severe hail	Fruit and gardens injured	Do.
Carroll, Gibson, and Shelby Counties, Tenn.	9					Hail	Hothouses and windows damaged	Do.
Chattanooga, Tenn., and vicinity.	10	3:22 a. m.				Thunderstorm	Wire systems, streets, sewers, and gardens damaged.	Do.
Arlberg, Ark	10	1:30 p. m.	3 mi.			Heavy hail	Crops injured; roofs pierced	Do.
Comanche, Cotton and Tillman Counties, Okla.	10	8 p. m.	6 mi.			do	Crops and property damaged over path 25 miles long.	Do.
Walters, Okla., and vicinity.	10	8:30 p. m.	3 mi.			Hail	Crops and property damaged over path 20 miles long.	Do.
Madison and Chambers Counties, Ala.	10					Heavy hail	Character of damage not reported	Do.
Brunswick, Mo	10					do	Little damage done owing to backward condition of crops.	Do.
Madison County, Fla	11	12:30 a. m.			1,000	Hail	Character of damage not reported	Do.
Palo Alto, Calif	11	12:30 p. m.	1,000			do	Truck gardens damaged	Do.
Del Rio, Tex	11	6-6:30 p.m.	50	1	18,000	Tornado	Houses unroofed; windows broken; oil derrick and buildings around it blown down; 30 persons injured.	Do.
Washita and Caddo Counties, Okla.	11	6:30 p. m.	220			Hail	Damage chiefly to crops; path 10 miles long	Do.
Minco (near) to Mustang, Okla.	11	7 p. m.	150	1	250,000	Tornado	12 houses completely demolished, others damaged; 7 persons injured; path 20 miles long.	Do.
Comanche, Okla., and vicinity.	11	9:30 p. m.	5 mi.			Heavy hail	Crop and property damage considerable; path 20 miles.	Do.
Citronelle and Gadsden, Ala.	11					do	Character of damage not reported	Do.
Perrine and Peters, Fla	11		4 mi.			do	About 10 per cent of tomato crop ruined	Do.
Nixon, Tex	11-12		30 mi.		50,000	Two hail storms	Heavy property and crop damage; also poultry killed.	Do.
Dearing (near), Kans	12	1:30 a. m.				Violent wind squall.	Outbuildings damaged; trees prostrated; one person injured.	Do.
Yoakum, Tex	12	11:30 a. m.			250,000	Hail	Severe crop damage; windows broken	Do.
Shiner, Tex	12	12:30 p. m.	1,760			do	All crops in area destroyed; poultry injured; path 12 miles.	Do.
McCurtain, Okla. (near), to Fort Smith, Ark.	12	P. m.	200	4	100,000	Tornado	Houses unroofed; trees uprooted; light buildings moved from foundations; 13 persons injured.	Do. Times Record (Fort Smith, Ark.).
Rocksprings-Leakey-Utopia, Tex.	12	7:50 p. m.	1,760	74	1,230,000	do	Town of Rocksprings practically destroyed; 205 persons injured; path 65 miles long.	Do.
Uvalde, Tex. (14 miles northwest of).	12	8 p. m.				do	All buildings in path wrecked	Do.
Uvalde, Tex. (7 miles northeast of).	12	P. m.				do	No damage reported	Do.
Robert Lee to Bronte, Tex.	13	12:05 a. m.	880		53,000	do	Considerable property damage over area covered; 5 persons injured.	Do.
Belton-Pendelton-Eddy, Tex.	13	5:30 a. m.	400-1,760		145,000	do	Many families homeless; livestock killed or injured; heavy loss to pecan and fruit trees.	Official, U. S. Weather Bureau. Temple Daily News (Tex.).
Arlington to Hebron, Tex.	13	7-8 a. m.	150	2	26,000	do	Considerable damage, character of which was not reported; 13 persons injured.	Official, U. S. Weather Bureau.
Ellis County, Tex	13	8 a. m.	880			do	Only slight damage reported; 1 person injured	Do.
Lufkin, Tex	13	2 p. m.	440	2	[2] 75,000	do	Several homes wrecked or unroofed [2]	Do.

[1] "Mi." signifies miles instead of yards.

[2] Damage includes that at Lufkin on the 14th.

Severe local storms, April, 1927—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Appleby, Tex	13	2-3 p. m	880			Hail	Cotton in path must be replanted; corn and gardens beaten.	Official, U. S. Weather Bureau.
Atlanta, Tex	13	2:45 p. m	150		$50,000	Tornado	Two business houses and a dozen others damaged; large trees uprooted.	Official, U. S. Weather Bureau. Dallas Morning News (Tex.).
Furnas County, Nebr	13	5-6 p. m				Hail	Considerable damage in places; some poultry killed; area 15 square miles.	Official, U. S. Weather Bureau.
Bryan, Tex	13					Wind	Damage principally to windows	Do.
Crockett, Tex	13				500,000	Wind and rain	Damage principally by rain	Do.
Furnas County, Nebr. (western).	13	P. m				Tornado	Barn wrecked; house moved	Do.
Desert, Tex. (3 miles north of).	13		50			Small tornado	Almost everything in path destroyed	Dallas Morning News (Tex.)
Godley and Joshua, Tex	13					Wind	Garages and autos damaged; livestock injured	Official, U. S. Weather Bureau.
Weimar, Tex	13					do	Several farm homes damaged	Do.
Woden, Tex	13					do	A schoolhouse, 3 residences, and 2 autos wrecked	Do.
Shiner, Tex	14	12:30 a. m	100			Tornado	Only moderate damage reported	Do.
Mount Selman to Walnut Grove, Tex.	14	1-2 a. m	200		4,000	do	Three houses blown down and damage to tomato and other crops.	Dallas Morning New (Tex.).
Titus County, Tex	14	3-4 a. m				Hail and wind	Several residences, barns, timber, etc., blown down.	Do.
Marshall, Tex. (5 miles south of).	14	4:45 a. m		1		Tornado	Many houses unroofed or otherwise damaged; telephone lines and trees damaged.	Do.
Lufkin, Tex	14	6:20 a. m	150		(1)	do	A mill and several other buildings wrecked	Official, U. S. Weather Bureau.
San Augustine, Tex	14	8:30 a. m				do	Moderate damage resulted	Do.
Greenwood, La. (2 miles east of).	14	8:41 a. m	880		5,700	Tornadic wind	Severe damage to trees, old structures, signs, etc.; bus loaded with school children overturned, injuring several.	Do.
Little Rock, Ark. (southwest of).	14	2:45 p. m			10,000	Tornado	Wires, buildings, and trees damaged; 5 persons injured.	Do.
Pine Bluff, Ark	14	3 p. m				Wind	Minor damage	Do.
Abbeville, La	15	3:30 a. m	7-10 mi.			Heavy hail	Some crop and property damage	Do.
Columbia, Miss	15					Thundersquall	Considerable local damage	Do.
Meridian, Miss	15			1		High wind	Large tent razed; minor injury to buildings, trees, etc.	Do.
Louisiana (southern in vicinity of New Orleans).	15-16					Thunderstorms	Extensive damage by flooding	Do.
Auburn, Calif	16	7 p. m	880		30,000	Heavy hail	Cherries and early plums almost total loss	Do.
Mobile, Ala	16				8,000	Thunderstorm	Shipbuilding company sustains heavy loss; other minor damage.	Do.
Arkona, Okla	17					Thunderstorm and wind.	16 houses damaged	Do.
Fort Smith, Ark	17					Thunderstorm	Glass broken; trees damaged	Do.
Washington	17					High winds	Winds throughout State cause damage to shipping and soil.	Do.
Washita County, Okla. (northeastern).	17		2-3 mi.		50,000	Heavy hail	Damage chiefly to crops over path 10 miles long	Do.
Van Arsdale, Kans. (near)	18	1:30 p. m	200		600	Tornado	Only small buildings and telephone lines damaged.	Do.
Harper to Eckert, Tex	18	5:30 p. m	300		80,000	do	Livestock killed; buildings wrecked; 7 persons injured.	Official, U. S. Weather Bureau; Dallas Morning News (Tex.).
Moore, Tex	18	7:30 p. m	200	2	6,000	do	1 home completely demolished; 8 persons injured.	Do.
Arkansas City, Kans	18	8 p. m				Small tornado	1 house damaged; telephone poles and trees blown down.	Official, U. S. Weather Bureau.
Granger, Tex. (5 miles northwest of).	18	do	60	2		do	Houses partly unroofed; trees and fences torn down over path 15 miles long; 4 persons injured.	Do.
Arthur City, Tex. to southeast Choctaw County, Okla.	18	11:30 p. m	440	1	60,000	do	Nearly every building in path demolished; 13 persons injured.	Do.
Blanco County, Tex. (Walnut and Blowout sections).	18	P. m				Tornado	Farm buildings and a church wrecked; several persons injured.	Dallas Morning News (Tex.).
Rockport, Ind	18					Heavy hail	Slight to considerable damage	Official, U. S. Weather Bureau.
Cave Springs, Mo. (near)	19	A. m				Tornadic wind	3 barns wrecked; a dwelling unroofed and a school house demolished.	Springfield Daily Morning News (Mo.).
Boone to Adair County, Mo., and east to Mississippi River.	19	10 a. m. to 12 noon.	6 mi.		10,500	Hail, wind, and rain.	Many bridges washed out; trains delayed; windows broken; roofs punctured; crops injured.	Official, U. S. Weather Bureau.
Quincy, Ill	19	10:20 a. m			12,000	Heavy hail	Much damage to fruits, roofs, windows, and auto tops.	Do.
East-central Boone County northeastward to Louisiana, Pike County, Mo.	19	11:30 a. m			60,000	Tornado	Tree tops twisted off; 30 buildings demolished or damaged; 4 persons injured.	Do.
Apex (4 miles southwest of), Mo., northeast to Ford-Livingston County line, Ill.	19	1 p. m	60-600	21	1,369,500	do	Many buildings wrecked, others damaged; much destruction of farm properties and crops. Path 170 miles long; 123 persons injured.	Do.
Washington County, Iowa	19	2 p. m	2,640		20,000	Wind	Character of damage not reported	Do.
Sanilac and Huron Counties, Mich.	19	7-8 p. m			125,000	Tornadic winds	Extensive property damage	Do.
Melvin (near), Mich	19	7:45 p. m	30			Small tornado	Trees uprooted; several barns demolished; many buildings twisted.	Do.
Clay-Park County, Ind	19				45,000	Tornadic wind	Damage of various kinds reported	Do.
Effingham County, Ill	19		60		15,000	Tornado	Considerable damage over path 15 miles long; 3 persons injured.	Do.
Kankakee County, Ill. (Aroma Park and vicinity).	19				50,000	Wind	Much property damage reported; 4 persons injured.	Do.
Macomb (near), Ill	19					do	Damage to 20 farm properties	Do.
Milwaukee, Wis	19				5,000	Severe squall	Area covered about 4 city blocks; 1 building moved; 14 poles blown down; many buildings damaged by water.	Do.
Stark, Bureau, Lee, DeKalb, McHenry, Kane, Ogle, and Lake Counties, Ill.	19				252,500	Violent winds	Overhead wires and trees blown down, buildings damaged; American Steel Wire Co. sustains heavy loss.	Do.

[1] Damage included in that of the 13th.

Severe local storms, April, 1927—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
West Union, S. C. (near)	19				$2,000	Electrical	Barn and contents destroyed	Official, U. S. Weather Bureau.
Winsor, Ill. (near)	19		50			Tornado	Minor damage to farm property; path 1 mile long.	Do.
Pryor to Choteau, Okla	20	6 p. m.	8 mi.			Moderate hail	Damage confined chiefly to crops	Do.
Abilene, Tex	20				3,500	High wind	Several frail buildings damaged; awnings torn	Do.
Nashville, Tenn	20					Severe thunderstorm and hail.	Quantities of peaches knocked off; trees and garden truck injured; telephones out of order; some damage by flooding.	Do.
Caps to Potosi, Tex	20				100,000	Heavy hail	Severe crop and property damage	Do.
Dallas, Tex	20-21					Thunderstorm	Residence struck by lightning and burned; 1 person injured.	Do.
Dubuque County, Iowa, westward.	20-21					Sleet	Overhead wires broken and a few poles snapped	Do.
Palestine, Tex	21	12:45 a. m.	100			Tornado	Considerable damage over small area; telephone and telegraph service crippled for several hours.	Do.
Harmon to Gross, La	21	2 a. m.	3,520		50,000	Thunderstorm and wind.	Tenant houses on several plantations wrecked; oil derricks overturned; timber damaged; wire communication impaired.	Do.
Ballard County, Ky	21					Wind and floods	43 homes moved from foundations by wind	Do.
Fort Gibson, Okla	25	9 p. m.				Small tornado	Several houses and barns demolished; trees uprooted.	Fort Smith Journal (Ark.).
Covington, Ind	27					Heavy hail	Damage slight to considerable	Official, U. S. Weather Bureau.
Queen Anne County, Md. (southwestern).	27					do	Gardens injured; windows broken	Do.
Hardy, Nebr. (near)	28	3:30 p. m.	100		5,000	Tornado	Farm buildings destroyed; path, 9 miles long.	Do.
Gage County (western) and Jefferson County (southeastern), Nebr.	28	6-7 p. m.	5		16,000	do	Several farm buildings wrecked; trees uprooted; path, 9 miles.	Do.
Anderson and Bourbon Counties, Ky.	29				30,000	Wind	Buildings damaged	Do.
Bedford, Scottsburg, and Shelbyville, Ind.	29					Heavy hail	Damage slight to considerable	Do.
Centralia, Ill., and vicinity	29		3,520		50,000	do	Extensive property damage; orchards not hurt	Do.
Louisville, Ky., and vicinity	29				20,000	Wind	Character of damage not reported	Do.
Marlinton, W. Va., and vicinity.	29					High wind	Roofs blown off; a schoolhouse and many trees blown down.	Do.
Fairwold, S. C	30	2 p. m.			5,000	Thundersquall	A dwelling and 2 stock barns damaged	Do.

STORMS AND WEATHER WARNINGS

WASHINGTON FORECAST DISTRICT

In connection with a disturbance over northeastern Missouri, which was moving eastward on the morning of the 1st, northeast storm warnings were ordered between Atlantic City and Boston, and for the next two days radio bulletins indicated strong winds off the Middle Atlantic coast. Winds occurred as forecast in the advices.

On the evening of the 6th, with a disturbance over the lower St. Lawrence valley, advices were issued by radio for strong winds on the following day along the Atlantic coast from Sandy Hook northward. Similar advices were distributed the morning of the 7th for the Middle and North Atlantic coast. Strong winds reaching gale force at times occurred substantially as indicated.

Special observations at 2 p. m. of the 9th indicated the development of a disturbance with probable northeast movement near Cape Hatteras, and northeast storm warnings were ordered from Delaware Breakwater to Boston. The disturbance, however, moved almost due east and winds on the coast were only fresh, but were strong off the coast in region of storm center, as far east as Bermuda.

Southeast storm warnings were ordered on the east Gulf coast between Bay St. Louis, Miss., and Apalachicola, Fla., on the morning of the 14th in connection with a disturbance over southeastern Texas. Winds were strong at times over the greater portion of the area indicated.

Small-craft warnings were ordered on the 20th from Delaware Breakwater to Eastport, on the 21st from Bay St. Louis, Miss., to Apalachicola, Fla., and on the 22d from Boston to Jacksonville.

On the morning of the 26th, with a disturbance of considerable intensity over Lake Huron, southwest storm warnings were hoisted from Delaware Breakwater to Eastport, and strong winds occurred. Small-craft warnings were also ordered south of Delaware Breakwater to Norfolk.

On the 17th storm warnings were ordered at 3 p. m. from Delaware Breakwater to Cape Hatteras in connection with a disturbance over Ohio, and strong winds and gales occurred over the region of display.

Small-craft warnings were hoisted at 10:30 a. m. of the 29th from Delaware Breakwater to Boston.

Warnings of frost or freezing temperatures were issued for considerable areas on the 11th, 20th, 22d, 23d, 24th, and 30th, and for limited areas on the 1st, 5th, 14th, and 21st, with timely accuracy in the great majority of cases.—*R. H. Weightman.*

CHICAGO FORECAST DISTRICT

The two outstanding features of the weather of April, 1927, in the Chicago forecast district were the frequency with which precipitation occurred, and the severe freeze at the beginning of the third decade. Not a single 12-hour period (considered as beginning at 7 a. m. and 7 p. m.) passed without at least 0.01 of an inch of precipitation somewhere in the district, while the freeze caused serious damage over a wide area in the southern portion of the district.

Frost warnings.—At the beginning of the month vegetation was subject to frost damage only in the extreme southern part of the district, but by the close this stage had been reached elsewhere in the forecast district, except in most of the Dakotas and the northern portions of Minnesota and Michigan. The only frost warning issued prior to the 14th was that on the 1st for southeastern Kansas, most of the fore part of the month having been cloudy and rainy.

On the morning of the 21st general warnings of freezing temperature or of heavy to killing frost were issued for practically all the southern half of the district. At that time an abnormally cold high pressure area overlay the

Rocky Mountain region and the Great Plains section. At Huron, S. Dak., the temperature fell to 13°, breaking all previous records there for so late in the season. The frost and freeze occurred as forecast and the resulting damage was, as has already been stated, serious over a wide area. The movement of this high-pressure area was sluggish, with the result that frost occurred successively on four nights in much of the southeastern part of the district. Another frosty period occurred at the close of the month in portions of the Lake region, and fruit and vegetables suffered further injury in lower Michigan. Most of these frosts were forecast.

Storm warnings.—The storm-warning season on the Great Lakes opened on the 10th—about five days earlier than usual. Prior to that date three advisory warnings were issued for Lake Michigan. These were on the 1st, 4th, and 8th. In the first two cases winds of storm force occurred over the lake. Those of the 4th were severe in certain cases where thunderstorms were an accompaniment. Thus, at Chicago the 5-minute maximum velocity was at the rate of 58 miles an hour, with an extreme velocity of 66 miles an hour. Furthermore, the Dines pressure tube anemometer registered a gust at the rate of 77 miles an hour.

After the beginning of the storm-warning season proper, either storm or small-craft warnings were issued on seven occasions.

On the night of the 12th northeast storm warnings were displayed along the west shore of Lake Michigan from Chicago to Sheboygan. Verifying winds occurred as forecast.

The next storm warning of importance was issued on the 19th for the upper Lakes. A disturbance of considerable intensity was at that time over the upper Mississippi and lower Missouri Valleys, with a cold high pressure area over the northwest—the same high-pressure area that later caused the severe freeze referred to in a previous paragraph. On the evening of this date the warnings were extended over the lower Lakes. They were verified on the upper Lakes and on extreme western Lake Erie.

Storm warnings were again issued on the 21st for all the Great Lakes except Lake Superior. These were verified only in part, but fresh to strong winds were general.

A timely small-craft warning for all the Great Lakes was issued on the night of the 25th, and again on the following night for the upper Lakes.

A well-defined storm was centered on the morning of the 29th over Missouri and appeared to call for storm warnings on Lakes Erie and the southern portions of Huron and Michigan. However, the storm took an east-southeast course, and the only verifying velocity reported was that at Chicago.—*C. A. Donnel.*

NEW ORLEANS FORECAST DISTRICT

Over the middle Mississippi Valley and western tributary basins, especially the basins of the White, Arkansas, Ouachita, and Red Rivers, heavy rainfall from April 7 to 16 resulted from low pressure over the Southwestern States, while the pressure was high over the Great Lakes and the north-central districts; and very heavy rains from the 19th to the 21st occurred during the passage of a trough of low pressure followed by an area of unusually high pressure. Occurring while a great flood was in progress, this remarkably heavy April rainfall resulted in far higher water on the Mississippi River, from Cairo to near the mouth, than had ever previously been recorded.

Southeast storm warnings were displayed from Morgan City to Brownsville at 8 p. m. of the 12th, because of a well-defined disturbance over the Rio Grande Valley. This disturbance moved slowly and the warnings were continued at 8 p. m. of the 13th, small-craft warnings having been displayed meanwhile on the Louisiana coast east of Morgan City. The warnings were verified.

Southeast storm warnings were displayed on the Texas coast from 8:30 p. m. of the 17th to 8:30 p. m. of the 19th because of a trough of low pressure which was attended by strong southerly winds to gales on the Texas coast.

On the night of the 20th–21st an area of high pressure advanced rapidly to the Texas coast, after the manner of a winter "norther," and northerly gales reached the east coast of Texas in the early morning of the 21st. Northwest storm warnings were displayed at 8:30 a. m. of the 21st on the Texas and Louisiana coasts and were justified; "norther" advices for Tampico, Mexico, were issued at this time.

Frost warnings for the northwestern and occasionally for the northeastern portion of the district were issued on the 1st, 17th, 20th, and 21st, the warnings of the 21st applying also to most interior sections of the southern portion. Conditions generally occurred as forecast.—*R. A. Dyke.*

DENVER FORECAST DISTRICT

Temperatures averaged considerably below normal in Montana, Wyoming, and northern Utah, and above normal in Colorado, New Mexico, and Arizona. There was an excess of precipitation in Wyoming and eastern Montana; elsewhere in the district amounts were below normal. The noteworthy feature of the month was the stormy weather in Wyoming extending from the 10th to the 16th, inclusive. During most of this week snowfall was state-wide and almost continuous. The amounts in the southern and eastern parts of the State were heavy, the accumulated depth on the ground at Cheyenne being 10 inches on the 14th. Traffic of all kinds, including the transcontinental air mail, was delayed considerably during this period. While livestock suffered considerably, there were no great losses. Warnings of frost or freezing temperature were issued almost every day, mostly for western Colorado, but occasionally for eastern Colorado, New Mexico, and southern Wyoming; these warnings were generally verified. Advices of fresh to strong winds were furnished the air mail services in southern Wyoming and eastern Colorado on the 2d, 3d, 8th, 9th, and 18th. No cold-wave warnings were issued.—*E. B. Gittings.*

SAN FRANCISCO FORECAST DISTRICT

The barometer was low over the lower latitudes of the ocean at the beginning of the month, a condition precedent to rather general rains in the Pacific States for a few days thereafter and calling for small craft warnings on the central California coast on the 1st. The barometer rose gradually over the ocean south of latitude 40°, while a disturbance which proved to be of persistent character developed in the upper Gulf of Alaska. A series of offshoots from the latter passed inland between the 2d and 7th, the last of which required the display of warnings at seaports in Oregon and Washington on the 6th. On the 8th the center of low pressure shifted inland from the Gulf of Alaska to the Great Basin consonant with a change in orientation of the major axis of the Pacific HIGH to a north-south trend. This situation prevailed until the 13th of the month, and during this

time temperatures over most of the district were below normal. Frost warnings were required for all or parts of Washington, Oregon, northern California, and Idaho from the 8th to the 13th, inclusive. This cold period was terminated by the entrance of a storm from the northern ocean on the 14th which required the display of storm warnings at northern ports, and this was followed by two successive depressions which formed in the upper Gulf of Alaska. At the same time a very strong and widespread increase in pressure took place over other parts of the northeast Pacific Ocean, and an oceanic HIGH developed similar in character to that which had occupied the ocean during the early part of the month when LOWS generated in the upper Gulf of Alaska. With the passing of the last low-pressure area from this sector the axis of the Pacific HIGH assumed a north-south direction, and southwest gales, for which warnings were displayed at northern ports on the 17th, were followed by colder weather in Washington, Oregon, Idaho, and Nevada. Frost warnings were issued for these States on the 18th, 19th, 20th, and 21st. The frosts which occurred on the two latter dates were unusually severe, especially in eastern Washington, eastern Oregon, and Idaho, where several stations reported the lowest April temperatures of record. No general warnings were issued thereafter until the close of the month.—*Thomas R. Reed.*

RIVERS AND FLOODS

By H. C. FRANKENFIELD

The great flood in the lower Mississippi Valley continued throughout the month and can not yet be properly discussed. After the flood has finally subsided a special report will be made in the form of a MONTHLY WEATHER REVIEW SUPPLEMENT. Perhaps it will be sufficient at this time to state only that the flood from Cairo, Ill., southward was the greatest in the history of the lower Mississippi Valley, although from New Orleans, La., to the Gulf of Mexico not the greatest as to actual stages, as the premeditated cutting of the levee at Caernavon, La., depressed the flood crest at New Orleans at least 2 to 2½ feet, and possibly a little more.

The following table shows the crest stages at certain river stations where they exceeded previous records, and also the highest recorded stages previous to 1927:

Station	Present flood crests		Previous records	
	Stage (feet)	Date (1927)	Stage (feet)	Date
Cairo, Ill	56.4	Apr. 20	54.7	Apr. 4, 1913[1]
Helena, Ark	56.8	Apr. 26–27	55.2	Apr. 22, 1913
Arkansas City, Ark	60.5	Apr. 21	58.0	Apr. 22, 1922[1]
Greenville, Miss	54.7	do	52.1	Apr. 25, 1922[1]
Vicksburg, Miss	58.7	May 4	55.0	Apr. 28, 1922[1]
Natchez, Miss	56.5	do	55.3	Apr. 26, 1922
Baton Rouge, La	47.8	May 15	45.7	May 16, 1922
Donaldsonville, La	37.1	May 15, 16, 17	35.9	Do.
Yazoo City, Miss	37.4	May 5	36.5	—— —, 1882
Alexandria, La	42.4	May 8	41.8	July 6, 1908
Melville, La	46.8	May 14, 15, 16	45.9	May 14, 1922[1]
Pine Bluff, Ark	32.4	Apr. 21	30.5	May 22, 1892

[1] And subsequent dates.

There were no high waters of consequence in the rivers of the Atlantic and East Gulf drainage, merely a few local rises to the flood stage or slightly higher, and without material losses.

The Ohio River was in moderate flood from Evansville to Mount Vernon, Ind., on April 16 and 17, and remained at very high stage throughout the month below the mouth of the Wabash River.

On account of frequent rains, the interior rivers of the State of Ohio were quite high during the month, although there were only a few minor overflows without resulting damage. The same was true of the Wabash River system, the rivers of which had been very high during the month of March also. The Tennessee River was not in flood during the month except at Johnsonville, Tenn., from April 15 to 18.

The floods in th upper Mississippi system as well as those in the Arkansas and Red systems will be treated as a portion of the great flood. It may be remarked that the Illinois River was continuously in great flood throughout the month.

Heavy rains on April 7 and 8 and again on April 18 and 19 over the drainage area of the Arkansas River from Witchita, Kans., to the Kansas-Oklahoma line caused more or less severe floods in the tributary streams and a crest of 20.0 feet, 5.0 feet above flood stage, in the Arkansas River at Arkansas City, Kans., on April 9.

The loss and damage, mainly along the tributary streams, amounted, as reported, to $235,500, of which $105,000 was in prospective crops. The reported value of property saved through the warnings was $45,000.

West Gulf drainage.—A series of heavy rains during the second and third decades of the month resulted in sustained floods of fair proportions in the Sabine, Neches, and Trinity Rivers, for which warnings were issued as required, beginning with April 13. A great quantity of livestock and other movable property was moved upon receipt of the warnings, and the reported value of property saved thereby was $50,000. Losses as given aggregated $58,500, all in the Trinity River area, and about equally divided between prospective crops and business suspension. A moderate flood in the Guadalupe River of Texas from April 14 to 18 was also well forecast, and virtually no losses resulted. There were also moderate floods from April 4 to 7 and April 27 to May 5 in the Rio Grande from below Albuquerque to San Marcial, N. Mex., that were well forecast. No reports of damage were received.

Pacific drainage.—No rises of consequence occurred except in the Colorado River and tributaries within the State of Colorado. They passed off without special incident.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC DRAINAGE					
	Feet			Feet	
James: Columbia, Va	18	Apr. 23	Apr. 23	18.5	Apr. 23
EAST GULF DRAINAGE					
Etowah: Canton, Ga	11	Apr. 11	Apr. 11	12.7	Apr. 11
Pearl: Jackson, Miss	20	Apr. 3	Apr. 9	21.9	Apr. 6
West Pearl: Pearl River, La	13	(1)	Apr. 6	16.4	Feb. 18
		Apr. 16	Apr. 19	13.5	Apr. 18
MISSISSIPPI DRAINAGE					
Ohio:					
Evansville, Ind	35	(1)	Apr. 6	39.9	Mar. 25
		Apr. 14	Apr. 18	36.4	Apr. 16
Dam No. 48, Cypress, Ind	35	(1)	Apr. 5	39.1	Mar. 26–29
		Apr. 15	Apr. 18	35.5	Apr. 17
Mount Vernon, Ind	35	(1)	Apr. 10	40.7	Mar. 31
		Apr. 13	Apr. 20	37.2	Apr. 17
Shawneetown, Ill	35	(1)	Apr. 24	44.3	Apr. 1
Paducah, Ky	43	Apr. 13	Apr. 24	47.2	Apr. 18
Cairo, Ill	45	(1)	(2)	56.4	Apr. 20
Tuscarawas: Gnadenhutten, Ohio	9	Apr. 3	Apr. 3	9.4	Apr. 3
Scioto: Larue, Ohio	11	Apr. 2	Apr. 2	11.8	Apr. 2
Green: Lock No. 2, Rumsey, Ky	34	(1)	Apr. 6	40.6	Mar. 27
		Apr. 16	Apr. 19	34.2	Apr. 17–18

[1] Continued from last month. [2] Continued at end of month.

River and station	Flood stage	Above flood stages—dates: From—	To—	Crest: Stage	Date
MISSISSIPPI DRAINAGE—continued	Feet			Feet	
Wabash:					
Lafayette, Ind	11	Apr. 2	Apr. 7	15.3	Apr. 3
		Apr. 10	Apr. 12	12.7	Apr. 11
		Apr. 18	Apr. 22	16.4	Apr. 20
Covington, Ind	16	Apr. 2	Apr. 8	19.0	Apr. 4
		Apr. 11	Apr. 12	16.4	Apr. 12
		Apr. 20	Apr. 24	19.9	Apr. 22
Terre Haute, Ind	16	Apr. 5	Apr. 12	17.7	Apr. 12
		Apr. 22	Apr. 25	16.5	Apr. 24
Vincennes, Ind	14	[1]	Apr. 18	19.5	Mar. 28
		Apr. 22	Apr. 28	14.8	Apr. 27
Mount Carmel, Ill	16	[1]	Apr. 29	24.3	Mar. 28
Tippecanoe: Norway, Ind	6	Apr. 2	[2]	6.5	Apr. 2, 10, 17-21, 26
White: Decker, Ind	18	[1]	Apr. 1	25.8	Mar. 27
		Apr. 7	Apr. 13	19.0	Apr. 11, 12
White, East Fork: Seymour, Ind	10	do	Apr. 7	10.4	Apr. 7
White, West Fork:					
Elliston, Ind	19	Apr. 3	Apr. 3	19.0	Apr. 3
		Apr. 6	Apr. 9	22.6	Apr. 8
Edwardsport, Ind	15	Apr. 8	Apr. 12	17.8	Apr. 9
Tennessee: Johnsonville, Tenn	31	Apr. 15	Apr. 18	32.2	Apr. 17
Elk: Fayetteville, Tenn	14	Apr. 11	Apr. 14	22.0	Apr. 13
Mississippi:					
Keokuk, Iowa	14	Apr. 3	Apr. 3	14.2	Apr. 3
		Apr. 20	Apr. 24	15.0	Apr. 21
Warsaw, Ill	17	do	Apr. 23	17.7	Do.
Quincy, Ill	14	Apr. 1	Apr. 7	16.0	Apr. 3
		Apr. 16	Apr. 26	17.5	Apr. 22
Hannibal, Mo	13	[1]	Apr. 29	18.0	Do.
Louisiana, Mo	12	Apr. 1	do	16.5	Apr. 23
Grafton, Ill	18	Apr. 2	[2]	25.8	Apr. 25
Alton, Ill	21	do	[2]	31.2	Do.
St. Louis, Mo	30	Apr. 4	Apr. 7	31.0	Apr. 5
		Apr. 13	[2]	36.1	Apr. 26
Chester, Ill	27	Apr. 3	[2]	34.5	Do.
Cape Girardeau, Mo	30	Apr. 2	[2]	40.0	Apr. 20-21
New Madrid, Mo	34	[1]	[2]	43.5	Apr. 21-22
Memphis, Tenn	35	[1]	[2]	46.0	Apr. 23
Helena, Ark	44	[1]	[2]	56.8	Apr. 26-27
Arkansas City, Ark	48	[1]	[2]	60.5	Apr. 21
Greenville, Miss	42	[1]	[2]	54.7	Do.
Vicksburg, Miss	45	[1]	[2]		
Natchez, Miss	46	[1]	[2]		
Angola, La	45	[1]	[2]		
Baton Rouge, La	35	[1]	[2]		
Donaldsonville, La	28	[1]	[2]		
New Orleans, La	17	[1]	[2]		
Des Moines:					
Tracy, Iowa	15	Apr. 20	Apr. 20	15.5	Apr. 20
Ottumwa, Iowa	10	Apr. 19	Apr. 23	12.7	Apr. 21
Illinois:					
Morris, Ill	13	Apr. 17	Apr. 24	19.8	Apr. 20
		Apr. 30	[2]		
Peru, Ill	14	[1]	[2]	23.2	Apr. 21
Henry, Ill	10	[1]	[2]	17.9	Apr. 23-24
Peoria, Ill	18	[1]	[2]	24.6	Do.
Havana, Ill	14	[1]	[2]	22.3	Apr. 26
Beardstown, Ill	14	[1]	[2]	25.2	Do.
Pearl, Ill	12	[1]	[2]	22.7	Apr. 26-27
Meramec:					
Steelville, Mo	12	Apr. 1	Apr. 2	18.4	Apr. 1
Pacific, Mo	11	do	Apr. 5	22.0	Apr. 3-4
		Apr. 9	Apr. 18	18.4	Apr. 17
		Apr. 21	Apr. 21	11.8	Apr. 21
Valley Park, Mo	14	Apr. 1	Apr. 5	27.2	Apr. 4
		Apr. 9	Apr. 22	23.6	Apr. 18
Bourbeuse: Union, Mo	12	Apr. 1	Apr. 3	19.0	Apr. 3
		Apr. 16	Apr. 16	12.0	Apr. 16
St. Francis:					
St. Francis, Ark	17	[1]	[2]	20.4	Apr. 18
Marked Tree, Ark	17	Apr. 9	[2]		
Missouri:					
Kansas City, Mo	22	Apr. 19	Apr. 22	24.8	Apr. 21
Waverly, Mo	23	do	Apr. 23	25.6	Do.
Boonville, Mo	21	Apr. 20	Apr. 25	24.0	Apr. 23
Hermann, Mo	21	Apr. 4	Apr. 4	21.0	Apr. 4
		Apr. 12	Apr. 28	26.8	Apr. 24
St. Charles, Mo	25	Apr. 1	Apr. 7	27.0	Apr. 5
		Apr. 11	Apr. 30	33.0	Apr. 24-25
Solomon: Beloit, Kans	18	Apr. 14	Apr. 18	28.9	Apr. 16
		Apr. 22	Apr. 22	19.5	Apr. 22
Grand:					
Gallatin, Mo	20	Apr. 1	Apr. 3	27.5	Apr. 3
		Apr. 10	Apr. 22	32.3	Apr. 21
Chillicothe, Mo	18	Apr. 2	Apr. 5	26.4	Apr. 4
		Apr. 10	Apr. 24	28.6	Apr. 22
Brunswick, Mo	12	Apr. 13	Apr. 26	18.2	Do.
Thompsons Fork: Trenton, Mo	20	Apr. 20	Apr. 21	20.8	Apr. 21
Osage:					
Osceola, Mo	20	Apr. 1	Apr. 4	24.6	Apr. 3
		Apr. 9	Apr. 29	30.4	Apr. 11
Warsaw, Mo	22	Apr. 1	Apr. 6	28.7	Apr. 3
		Apr. 9	Apr. 20	34.4	Apr. 17
Tuscumbia, Mo	25	Apr. 1	Apr. 8	31.1	Apr. 4
		Apr. 11	Apr. 29	36.8	Apr. 18

[1] Continued from last month.
[2] Continued at end of month.

River and station	Flood stage	Above flood stages—dates: From—	To—	Crest: Stage	Date
MISSISSIPPI DRAINAGE—continued	Feet			Feet	
Arkansas:					
Arkansas City, Kans	19	Apr. 9	Apr. 9	20.0	Apr. 9
Ralston, Okla	16	Apr. 21	Apr. 21	16.0	Apr. 21
Webbers Falls, Okla	23	Apr. 12	Apr. 25	33.5	Apr. 15
Fort Smith, Ark	22	do	Apr. 28	36.7	Apr. 16
Dardanelle, Ark	20	Apr. 13	[2]	32.7	Apr. 19
Little Rock, Ark	23	Apr. 15	Apr. 30	33.0	Apr. 20
Pine Bluff, Ark	25	do	[2]	32.4	Apr. 21
Yancopin, Ark	29	[1]	[2]	48.5	Apr. 20
Neosho:					
Neosho Rapids, Kans	22	Apr. 16	Apr. 17	23.6	Apr. 17
		Apr. 20	Apr. 22	25.8	Apr. 20
LeRoy, Kans	24	Apr. 18	Apr. 23	27.3	Apr. 19
Iola, Kans	15	Apr. 19	Apr. 20	20.4	Do.
Oswego, Kans	17	Apr. 1	Apr. 5	19.3	Apr. 2
		Apr. 8	Apr. 27	25.4	Apr. 23
Wyandotte, Okla	23	Apr. 13	Apr. 20	29.5	Apr. 15
Pensacola, Okla	24	Apr. 14	do	32.0	Do.
Fort Gibson, Okla	22	Apr. 3	Apr. 4	23.0	Apr. 3
		Apr. 11	Apr. 25	34.5	Apr. 15
Cottonwood: Emporia, Kans	20	Apr. 2	Apr. 2	20.3	Apr. 2
		Apr. 15	Apr. 17	23.5	Apr. 16
		Apr. 19	Apr. 22	24.0	Apr. 20
Cimarron: Perkins, Okla	9	Apr. 20	Apr. 20	9.5	Do.
Verdigris: Okay, Okla	27	Apr. 14	Apr. 20	32.0	Apr. 18
North Canadian: Oklahoma City, Okla.	12	Apr. 12	Apr. 13	14.3	Apr. 13
Petit Jean: Danville, Ark	20	Apr. 11	Apr. 25	28.5	Apr. 15
White:					
Ozark Beach, Mo	30	Apr. 14	Apr. 17	38.0	Apr. 16
Calico Rock, Ark	18	Apr. 13	Apr. 23	49.5	Apr. 15
Batesville, Ark	23	Apr. 12	Apr. 24	42.3	Apr. 15
Newport, Ark	26	do	Apr. 30	35.6	Apr. 16-17
Georgetown, Ark	22	Apr. 8	[2]	30.3	Apr. 17
Clarendon, Ark	30	Apr. 16	[2]	43.3	Apr. 23
Buffalo: Gilbert, Ark	30	Apr. 14	Apr. 15	37.0	Apr. 14
Black:					
Leeper, Mo	11	Apr. 1	Apr. 1	16.0	Apr. 1
		Apr. 14	Apr. 16	16.5	Apr. 15
Williamsville, Mo	11			15.5	Apr. 1
				17.8	Apr. 15
Poplar Bluff, Mo	14	Apr. 2	Apr. 4	17.7	Apr. 2
		Apr. 10	Apr. 10	14.3	Apr. 10
		Apr. 13	Apr. 22	18.5	Apr. 16
Corning, Ark	11	[1]	[2]	16.2	Apr. 18
Black Rock, Ark	14	[1]	[2]	30.2	Apr. 15
Cache: Patterson, Ark	8	[1]	Apr. 7	10.5	Mar. 27
		Apr. 12	[2]	16.0	Apr. 19
Yazoo: Yazoo City, Miss	25	[1]	[2]		
Tallahatchie: Swan Lake, Miss	25	[1]	[2]	31.8	Mar. 22
Red:					
Arthur City, Tex	27	Apr. 16	Apr. 16	27.0	Apr. 16
Index, Ark	27	Apr. 18	Apr. 27	30.8	Apr. 23
Fulton, Ark	28	Apr. 16	[2]	35.0	Apr. 24
Springbank, Ark	37	Apr. 23	[2]	40.2	Apr. 27-28
Alexandria, La	36	Apr. 20	[2]		
Little: Whitecliffs, Ark	28	Apr. 16	Apr. 27	29.9	Apr. 24
Sulphur:					
Ringo Crossing, Tex	20	Apr. 7	Apr. 18	26.3	Apr. 15
		Apr. 22	Apr. 24	21.0	Apr. 23
Finley, Tex	24	Apr. 11	Apr. 26	28.2	Apr. 19
Cypress: Jefferson, Tex	18	Apr. 12	Apr. 16	19.1	Apr. 13
		Apr. 20	Apr. 23	19.6	Apr. 21
Ouachita:					
Arkadelphia, Ark	18	Apr. 15	Apr. 17	21.9	Apr. 15
		Apr. 21	Apr. 23	23.9	Apr. 23
Camden, Ark	30	Apr. 16	Apr. 30	41.0	Apr. 25
Monroe, La	40	[1]	[2]		
Atchafalaya: Melville, La	37	[1]	[2]		
WEST GULF DRAINAGE					
Sabine:					
Logansport, La	25	Apr. 15	[2]	29.2	Apr. 19
Bon Wier, Tex	20	Apr. 20	Apr. 24	20.6	Apr. 21
Neches: Rockland, Tex	22	Apr. 21	Apr. 21	22.0	Do.
Trinity:					
Dallas, Tex	25	Apr. 14	Apr. 16	28.1	Apr. 15
		Apr. 19	[2]	33.1	Apr. 21
Trinidad, Tex	28	Apr. 14	[2]	36.7	Apr. 20
Long Lake, Tex	40	Apr. 22	Apr. 28	40.5	Apr. 23
Liberty, Tex	25	Apr. 18	[2]	27.4	Apr. 21
Little: Little River, Tex	30	Apr. 14	Apr. 14	35.0	Apr. 14
Gaudalupe:					
Gonzales, Tex	22	do	do	23.9	Do.
Victoria, Tex	16	Apr. 15	Apr. 19	24.6	Apr. 18
Rio Grande: San Marcial, N. Mex	2	Apr. 1	Apr. 16	2.8	Apr. 7
		Apr. 27	[2]	3.0	Apr. 29
PACIFIC DRAINAGE					
Gunnison: Delta, Colo	9	Apr. 29	[2]		
Gunnison, North Fork: Paonia, Colo	9	Apr. 30	[2]		

[1] Continued from last month.
[2] Continued at end of month.
[3] Gage carried away Apr. 29.

MEAN LAKE LEVELS DURING APRIL, 1927

By UNITED STATES LAKE SURVEY

[Detroit, Mich., May 5, 1927]

The following data are reported in the "Notice to Mariners" of the above date:

Data	Lakes [1]			
	Superior	Michigan and Huron	Erie	Ontario
Mean level during April, 1927:	*Feet*	*Feet*	*Feet*	*Feet*
Above mean sea level at New York	601.41	578.78	571.75	245.97
Above or below—				
Mean stage of March, 1927	+0.10	+0.30	+0.65	+0.26
Mean stage of April, 1926	+1.31	+0.96	+0.94	+1.05
Average stage for April, last 10 years	−0.03	−1.06	−0.25	+0.06
Highest recorded April stage	−1.28	−4.45	−2.43	−2.46
Lowest recorded April stage	+1.31	+0.96	+0.94	+1.13
Average departure (since 1860) of the April level from the March level	+0.06	+0.23	+0.54	+0.59

[1] Lake St. Clair's level: In April, 1927, 574.15 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, APRIL, 1927

By J. B. KINCER

General summary.—At the beginning of the month temperatures were rather moderate, with an extensive storm area moving eastward over the interior valley States accompanied by unsettled, rainy weather. Following the passage of this LOW, a high-pressure area advanced eastward attended by somewhat lower temperatures, but thereafter it became warmer over Northern States. In the Southwest the weather was persistently warm with local reports in central Gulf districts of record high temperatures for so early in the season. Rainy weather continued in the interior States during the second decade with rain occurring every day during the first part with heavy to excessive rains over the lower Mississippi River further aggravating the already serious flood conditions that had prevailed along the trans-Mississippi States. Cessation of rains made more favorable weather during the last decade over central areas and temperatures continued abnormally high over eastern sections. Cooler weather overspread the central portions of the country about the 22d, and toward the close of the month subnormal temperatures prevailed quite generally in most States east of the Rocky Mountains.

Temperatures were rather too cool for best growth of crops the first part of the month, especially in northern sections, but the moderate to abnormal warmth in central and southern portions favored rapid advance. In the interior valleys field work was delayed by continued rains or wet soil, and these conditions prevailed well into the second decade with some damage by heavy rains flooding lowlands and washing soil in parts of the southern Great Plains. Conditions were favorable for field operations during the latter part of the second decade in more Eastern States, but in parts of the Southeast rain was badly needed with some western Gulf districts and parts of the Southwest lacking moisture. The soil continued saturated in most central areas with a consequent delay in field work, and plowing and spring planting were seriously delayed, but toward the close of the month more favorable weather enabled farm work to advance wherever the soil had dried out. The cold weather the latter part was decidedly unfavorable and more or less damage resulted to fruits and tender vegetation over a wide area from the southern Great Plains eastward to the Appalachian Mountains.

Small grains.—Good growing conditions for winter cereals prevailed quite generally during the first decade and the progress of the wheat crop was mostly satisfactory, except where moisture was needed in parts of the Great Plains area. The weather was mostly unfavorable during the second decade with heavy to excessive rains over the central and western portions of the wheat belt and some flooding and washing, but under the prevailing mild temperatures wheat made good advance where it was not too wet or flooded. Cool weather checked growth somewhat the latter part and toward the close there were complaints of plants yellowing on lowlands of the lower central valleys because of persistently wet conditions, but outside of the inundated districts generally good growth was reported.

Corn and cotton.—The persistently wet soil in most central sections considerably retarded the progress of corn planting and at the close of the month this work had progressed only as far north as southern Virginia and locally in the Ohio Valley, with planting begun in most portions of Kansas.

Cotton planting made fairly good advance in most portions the first part of the month, with seeding becoming more active toward the close of the first decade, although some central sections of the belt were too wet. The northeastern cotton districts were too dry and rain and warmer weather were needed, but in most other areas planting made satisfactory progress. It made good advance the latter part and was well along as far north as central South Carolina and extending into northern Georgia. Chopping was progressing in more southern districts. In Texas progress of the early crop was poor, due to cold, wet soil, and in other parts of this State dry weather with high winds was detrimental.

Ranges, pastures, and livestock.—Pastures made generally good advance during the month in most northern sections east of the Mississippi River, but in the Southeast rain was needed. Except for some local areas where it was too dry, ranges were mostly good in western areas. Livestock were in generally good condition, but some losses occurred in several States due to cold, stormy weather.

Miscellaneous crops.—Potato planting advanced during the month northward to South Dakota and the western Lake region and, except for some local frost injury, the crop did well generally. Truck crops also were favorably affected, except for some local frost injury and where the moisture was deficient, particularly in the Southeast. Sugar beets were mostly planted in Colorado at the close of the month and seeding was being rushed in Wyoming. Tobacco transplanting made good advance, but was awaiting warmer weather in some northern areas.

Fruits did well the first part of the month, but during the last decade more or less frost injury was reported from many sections in the south-central portions of the country. Citrus were affected adversely during most of the month in Florida, due to lack of rain, with much dropping reported at the close, but generally satisfactory condition prevailed in California.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

A marked decrease was noticed in the number of days with gales during April as compared with March. In the former month they were not reported on more than 4 days in any 5° square, or on more than 2 days east of the thirtieth meridian. Another noticeable feature was that over 80 per cent of the gales occurred in the first half of the month.

Fog over the Grand Banks was less frequent than usual, while the number of days on which it occurred was not far from the normal along the American coast between Hatteras and Newfoundland and considerably above over the steamer lanes between the twentieth and thirty-fifth meridians, where it was reported on from 6 to 9 days.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (seventy-fifth meridian), North Atlantic Ocean, April, 1927*

Stations	Average pressure	Departure [1]	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Belle Isle, Newfoundland	29.81	−0.02	30.36	22d	28.92	10th.
Halifax, Nova Scotia	29.97	+.08	30.50	4th [2]	29.26	28th.
Nantucket	30.04	+.06	30.42	15th	29.48	Do.
Hatteras	3C.10	+.09	30.42	do	29.72	30th.
Key West	30.03	+.01	30.10	1st [2]	29.92	Do.
New Orleans	30.04	+.04	30.34	22d [2]	29.82	Do.
Swan Island	29.88	−.10	29.94	1st	29.80	Do.
Turks Island	30.07	+.05	30.16	do	29.96	28th.
Bermuda	30.12	+.12	30.32	21st	29.58	10th.
Horta, Azores	30.16	+.05	30.54	12th	29.78	27th.
Lerwick, Shetland Islands	29.66	−.14	30.06	16th	29.13	22d.
Valencia, Ireland	30.04	+.15	30.40	do	29.50	8th.
London	29.96	+.09	30.37	12th	29.46	9th. [2]

[1] From normals shown on Hydrographic Office Pilot Chart based on observations at Greenwich mean noon, or 7 a. m., seventy-fifth meridian.
[2] And on other dates.

The results for Julianehaab, Greenland, are omitted, as observations for 12 days are missing. Judging from reports received from that place there was a period of low pressure there during the second decade, with a minimum barometric reading of 29.26 inches on the 15th. Anticyclonic conditions prevailed during the last decade, apparently culminating on the 25th or 26th, as readings of 30.36 inches were recorded on both dates.

On the 1st there were three well-defined disturbances over the ocean; the first, a shallow depression off the American coast between Hatteras and the Virginia capes; the second, central near Sydney, Nova Scotia, and the third near 45° N., 35° W. On the 2d the position of these LOWS had changed but little, and on both dates moderate gales were reported by a number of vessels west of the thirtieth meridian. By the 3d the first disturbance had increased in intensity and was central near 36° N., 66° W., with strong northeast gales prevailing between the Bermudas and coast of Maine; the second and third disturbances had apparently combined, and occupied the position of the latter on the previous day, while moderate westerly gales occurred in the southerly quadrants.

During the next 24 hours both of the LOWS moved rapidly eastward, and on the 4th the center of the western was near 33° N., 45° W., and the eastern near 53° N., 22° W., while gales of increased force still prevailed between the forty-fifth and fifty-fifth parallels, and the twentieth and thirty-fifth meridians. On the 5th the eastern disturbance was near 57° N., 15° W., and on the 6th off the north coast of Scotland, while on both dates moderate weather prevailed over the greater part of the ocean.

The eastern LOW moved but little during the next 24 hours, while on the 7th a depression moved over Newfoundland, and strong southwest gales prevailed between the Bermudas and the fortieth parallel, the station at New York reporting, wind NW., force 9. On the same day northwesterly gales were also reported over the eastern section of the steamer lanes.

Charts VIII to XI show the conditions from the 8th to 11th inclusive, which was the stormiest period of the month.

On the 12th southerly to westerly gales occurred over a limited area in mid-ocean, and northerly gales in the North Sea. On the same day, and also on the 13th, a well-developed depression was over the Straits of Gibraltar, and vessels in that vicinity, as well as along the coasts of Spain and Portugal, encountered winds of force 7 to 8.

On the 13th and 14th an area of low pressure overspread the western section of the Gulf of Mexico, although judging from reports received to date, it was not accompanied by heavy winds.

On the 15th and 16th anticyclonic conditions prevailed generally, except that on the latter date and also on the 17th there was an area of low pressure off the south coast of Iceland, attended by strong westerly gales in the southerly quadrants.

On the 17th St. Johns, Newfoundland, was about 300 miles north of the center of a LOW that remained nearly stationary during the next 24 hours and then moved slowly northeastward. On the 18th northerly gales were reported by vessels in the westerly quadrants.

On the 20th an area of low pressure was central near 50° N., 35° W., accompanied by moderate weather near the center, while gales were reported between the thirty-fifth and forty-second parallels, near the thirty-fifth meridian.

On the 22d and 23d the stations on the north coast of the Gulf of Mexico reported high barometric readings, Galveston recording 30.42 inches on the 22d. As a result of this high pressure a moderate "norther" prevailed in the Gulf on both days.

On the 22d an area of low pressure to the southward of Iceland was responsible for southwesterly gales off the coasts of Scotland and northern Ireland.

On the 23d one of those peculiar disturbances that sometimes appear suddenly in southern waters was central near 35° N., and 45° W.; the storm area was of limited extent but the force of the wind was the highest reported during the month, as shown by the storm report of the British steamship *Tiverton*.

On the 25th Shields, England, was near the center of a deep depression and westerly winds of force 7 prevailed as far west as the twentieth meridian.

On the 27th Father Point, Quebec, was near the center of a LOW that drifted slowly eastward and on the 30th was off the west coast of Newfoundland. On the 28th gales were encountered by vessels in the southerly quadrants, and winds of force 8 were reported by the land stations at New York and Port au Basque, Newfoundland.

OCEAN GALES AND STORMS, APRIL, 1927

Vessel	Voyage From—	Voyage To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began	Time of lowest barometer	Gale ended	Lowest barometer (Ins.)	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
North Atlantic Ocean			° ′	° ′									
Standijk, Du. S. S.	Rotterdam	New York	45 48 N.	36 13 W.	Mar. 31	9a., Apr. 1	Apr. 1	29.53	E.	N., 8	NNE	N., 8	S.-W.-N.
Grete, Ger. S. S.	Savannah	Bremen	39 15 N.	57 10 W.	Mar. 31	2a., 1	Apr. 1	29.81	SSW	SW., —	WNW	SSW., 9	SSW.-W.-WNW.
Maravi, Br. S. S.	New York	Banes, Cuba	36 20 N.	74 09 W.	Apr. 1	7p., 1	Apr. 3	29.63	E.	WSW., 5	WNW	W., 8	SW.-NNW.
Bellflower, Am. S. S.	Liverpool	Boston	47 29 N.	37 49 W.	Apr. 2	9a., 2	Apr. 3	29.48	WSW	WSW., 7	NW	W., 9	SE.-S.-W.
Englewood, Am. S. S.	Bremen	New York	36 50 N.	66 51 W.	Apr. 3	4a., 3	Apr. 3	29.63		NW., —		NW., 10	SSW.-NW.
Ala, Am. S. S.	Antwerp	Boston	50 45 N.	18 15 W.	Apr. 4	Noon, 4	Apr. 5	29.41	WSW	WSW., 9	W	W., 9	WSW.-W.
Woensdrecht, Du. S. S.	Texas City	Thameshaven	37 45 N.	63 45 W.	Apr. 5	Mdt. 4	Apr. 5	30.08	SE	SE., 8	E	E., 9	NE.-E.
Blue Triangle, Am. S. S.	Gibraltar	Boston	40 43 N.	58 08 W.	Apr. 7	Noon, 7	Apr. 7	29.73	S	SSW., —	W	—, 10	
United States, Dan. S. S.	New York	Christianssand.	55 45 N.	21 44 W.	Apr. 6	3p., 7	Apr. 9	29.55	WNW	NW., 5	N	WNW., 8.	WNW.-N.-NE.
Alberta, Ital. S. S.	Gibraltar	Philadelphia	35 28 N.	62 58 W.	Apr. 8	2p., 8	Apr. 9	29.86	WNW	WNW., 8	WNW	NNW., 9	
Thuringia, Ger. S. S.	Cobh	Boston	42 38 N.	55 56 W.	Apr. 9	8a., 9	Apr. 10	29.42	NNW	N., 7	NW	—, 10	NNW.-N.
Weirbank, Br. M. S.	Gibraltar	do.	38 21 N.	41 59 W.	Apr. 8	2a., 10	Apr. 11	29.63	ESE	WSW., 8	SW	S., 10	S.-WSW.
Am. Trader, Am. S. S.	New York	London	39 10 N.	55 00 W.	Apr. 8	2p., 10	Apr. 10	29.64	NW	W., 4	W	NW., 9	WNW.-W.
Wellfield, Br. M. S.	Hull	Key West	33 47 N.	54 29 W.	Apr. 10	1a., 11	Apr. 11	29.29	SW	SW., 9	WNW	W., 9	SW.-WNW.
West Campgaw, Am. S. S.	Portland, Me.	Hamburg	42 37 N.	43 30 W.	Apr. 11	6a., 11	Apr. 12	29.62	S	S., 8	SSW	S., 10	Steady.
Homestead, Am. S. S.	New York	Port Said	36 42 N.	1 29 W.	Apr. 12	8p., 12	Apr. 13	29.55	ENE	NE., 10	E	NE., 9	ENE.-NE.
El Oso, Br. S. S.	Port Said	Rotterdam	41 00 N.	9 40 W.	Apr. 12	—, 12	Apr. 14	30.21	NNE	NNE., 9	NNE	—, 10	Steady.
Huntsman, Br. S. S.	Savannah	New Orleans	28 21 N.	88 38 W.	Apr. 16	3p., 16	Apr. 16	29.84	SE	S., 9	SW	S. 9	S.-SW.
Casper, Am. S. S.	Gothenberg	Norfolk	58 09 N.	17 20 W.	Apr. 16	7p., 16	Apr. 17	29.58	SW	SW., 10	W	SW., 10	SW.-W.
Marie Leonhardt, Ger. S. S.	Antwerp	Porto Rico	29 57 N.	48 17 W.	Apr. 19	1p., 19	Apr. 19	29.74	N	NNE., —	NNE	NNE., 9	
Deer Lodge, Am. S. S.	Rotterdam	Galveston	41 00 N.	32 45 W.	Apr. 20	11a., 20	Apr. 20	29.65	SSW	SSW., 9	NNW	SSW. 9	SSW.-W.-NNW.
Gulfbreeze, Am. S. S.	Port Arthur	Boston	Port Arthur, Tex.		Apr. 21	8a., 21	Apr. 23	30.16	N	N., 8	NE	N., 8	Steady.
Stockholm, Swed. S. S.	Gothenburg	New York	58 30 N.	8 00 W.	Apr. 22	4p., 22	Apr. 23	29.26	SW	W., 8	NW	W., 8	SW.-NW.-W.
Tiverton, Br. S. S.	Liverpool	Houston	37 25 N.	45 03 W.	Apr. 22	4p., 23	Apr. 24	29.47	SE	NE., 10	NNE	ENE., 11	SE.-E.-NNE.
Gudrun Maersk, Dan. S. S.	Port Said	Bremerhaven	53 11 N.	4 23 E.	Apr. 25	Mdt., 25		29.17	WSW	NW., 9		NW., 9	WSW.-NW.
Gulfbreeze, Am. S. S.	Port Arthur	Boston	37 05 N.	72 45 W.	Apr. 27	9p., 27		29.44	SW	SW., 7		NW., 10	SW.-NW.
North Pacific Ocean													
West Himrod, Am. S. S.	Yokohama	Seattle	48 34 N.	176 21 E.	Apr. 1	8a., 1	Apr. 1	29.75	N	N., 8	E	N., 10	N.-NE.-E.
Tamaha, Br. S. S.	San Pedro	Shanghai	31 00 N.	137 00 E.	Apr. 6	4a., 6	Apr. 6	29.83	NW	NW., 7	NNW	NW., 8	NW.-NNW.
Biyo Maru, Jap. S. S.	Miike	Vancouver	38 17 N.	146 24 E.	Apr. 5	4p., 5	Apr. 7	29.97	ESE	ESE., 9	ESE	ESE., 9	Steady.
Fukuyo Maru, Jap. S. S.	do.	Grays Harbor	44 07 N.	164 15 E.	Apr. 4	Noon, 4	Apr. 9	29.86	N	NNW., 8	NW	NW., 9	
Tacoma, Br. S. S.	Shanghai	San Pedro	44 30 N.	176 00 E.	Apr. 7	Midt, 7	Apr. 8	29.39	NE	NNW., —	W	NW., 10	NE.-N.-W.
Somedono Maru, Jap. S. S.	Muroran	Willapa	47 28 N.	178 00 W.	Apr. 7	2p., 8	Apr. 10	29.39	N	NW., —	NW	WNW., 9.	4 pts.
Reiyo Maru, Jap. S. S.	Miike	Los Angeles	45 10 N.	176 00 E.	Apr. 10	3a., 10	Apr. 10	30.12	NW	NW., 8	NNW	NW., 8	Steady.
Arizona Maru, Jap. S. S.	Yokohama	Victoria	44 41 N.	160 14 E.	Apr. 11	2p., 11	Apr. 12	29.88	E	E., 9	E	E., 9	Do.
West Nomentum, Am. S. S.	do.	Portland	49 40 N.	138 45 W.	Apr. 13	10p., 13	Apr. 14	29.52	NNW	NNW., 7	NW	NNW., 9	Do.
Lurline, Am. S. S.	Seattle	Honolulu	28 56 N.	151 09 W.	Apr. 15	8p., 15	Apr. 15	29.96	ENE	ENE., 8	N	ENE., 8	ENE.-N.
Yoneyama Maru, Jap. S. S.	Puget Sound	Yokohama	49 52 N.	130 18 W.	Apr. 15	8p., 14	Apr. 15	29.68	NW	NW., 8	NW	NW., 8	Steady.
Absia, Du. S. S.	Saidozaki	San Pedro	36 52 N.	153 10 W.	Apr. 16	6p., 16	Apr. 17	29.88	E	ENE., 8	S	ENE., 8	ENE.-ESE.
Pres. Jefferson, Am. S. S.	San Francisco	Yokohama	34 36 N.	150 45 E.	Apr. 16	8p., 16	Apr. 17	29.67	W	W., 7	NNW	NW., 8	W.-NNW.
West Kader, Am. S. S.	Kobe	Columbia River.	38 10 N.	144 42 E.	Apr. 16	3p. 16	Apr. 19	29.24	NW	NW., 8	N	NW., 8	Steady.
West Niger, Am. S. S.	Yokohama	Portland	39 50 N.	149 27 E.	Apr. 12	10p., 13	Apr. 20	29.72	NW	NW., 7	NNW	ENE., 8	NW.-NE.
Yoneyama Maru, Jap. S. S.	Puget Sound	Yokohama	52 00 N.	157 00 W.	Apr. 21	5p., 21	Apr. 22	29.39	NNE	NNE., 8	N	NNE., 8	NNE.-N.
Tuscaloosa City, Am. S. S.	New York	Pacific coast	In Gulf of Tehuantepec.		Apr. 21	11a., 22	Apr. 23	29.82	NW	E. 10	NW	E., 10	Steady E.
Niagara, Br. S. S.	Honolulu	Victoria	32 00 N.	147 00 W.	Apr. 24	4a., 25	Apr. 25	29.76	W	NW., —	NNW	NW., 8	WNW.-NW.
Yoneyama Maru, Jap. S. S.	Puget Sound	Yokohama	47 15 N.	164 25 E.	Apr. 28	9a., 29	Apr. 29	29.37	NE	NE., 9	N	NE., 9	NE.-N.
West Niger, Am. S. S.	Yokohama	Portland	46 53 N.	138 36 W.	Apr. 30	6p., 30	May 1	29.64	NW	NW., 8	W	NW., 9	

NORTH PACIFIC OCEAN

By WILLIS E. HURD

The Aleutian LOW showed more than ordinary disintegration for the month in April, 1927. It lay over Bering Sea and the islands southwest of Alaska on only a few days, its activities being mostly confined to the upper and eastern waters of the Gulf of Alaska, this principally during the first 6 and the last 10 days of the month. Its general center, as in March, lay near Kodiak. West of the Peninsula of Alaska pressure on the average was much above normal, and during most of the month an anticyclone was situated over Bering Sea.

The North Pacific HIGH was composed, generally speaking, of two parts, one lying off the coast of California, the other in middle latitudes west of the one hundred and sixtieth meridian of west longitude. Between the two a few intruding shallow LOWS caused brisk winds, which at times rose to force 8, over the western part of the California-Hawaiian routes on the 15th, 17th, 24th, and 25th.

The pressure conditions at various island and coast stations in west longitudes are shown in the following table:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean, April, 1927*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Dutch Harbor [1, 4]	30.04	+0.21	30.46	3d	29.00	8th.
St. Paul [1, 4]	30.17	+0.37	30.68	2d	29.18	8th.
Kodiak [1, 4]	29.78	−0.02	30.36	17th	29.36	23d.[5]
Midway Island [1, 4]	30.04	−0.06	30.24	23d	29.62	5th.
Honolulu [3]	30.01	−0.06	30.11	29th	29.88	10th.
Juneau [3]	29.88	−0.08	30.40	18th	29.45	27th.
Tatoosh Island [2, 3]	30.02	−0.02	30.49	20th	29.51	6th.
San Francisco [2, 3]	30.03	−0.01	30.19	4th	29.83	10th.
San Diego [2, 3]	30.00	+0.04	30.16	1st	29.88	17th.

[1] P. m. observation only.
[2] A. m. and p. m. observations.
[3] Corrected to 24-hour mean.
[4] For 29 days.
[5] On other date.

Owing to the position of the Hawaiian Islands with reference to the western part of the anticyclone already referred to, the northeast trades prevailed with unusual steadiness at Honolulu. The maximum wind velocity at this station was 35 miles an hour from the northeast on the 13th; the average hourly velocity was 9.7 miles.

Exceptionally cool weather for the season occurred off the lower coast of Alaska. At Juneau this was the coldest April on record, the average temperature being 34°, which is 1° lower than that of the previous low record in 1890 and 7° below the normal.

Unsettled weather prevailed in middle and upper Asiatic waters owing to the rapid succession of high and low pressure areas, incident to the time of year, which came from the continent. No severe storms occurred off these coasts, but on several dates there were fresh gales south and east of Japan, accompanying eastward-moving depressions which skirted the islands. There were no disturbances of a tropical nature in the Far East this month.

April is not ordinarily a very stormy month on the North Pacific, but there were fewer gales than usual on the ocean this year. These few occurred largely in middle and higher latitudes along the western reaches of the sailing routes between America and Asia, and were mostly of forces 8 or 9. On the 1st, 6th, 7th, and 22d gales attained the maximum force of 10 for the month. The whole gales of the 1st and 7th were experienced by steamers near longitude 176° E., latitudes 48° and 44°, respectively. Early in April some moderate to fresh gales occurred off the Washington coast, among them being a whole gale of short duration—a 61-mile wind from the southwest—recorded by the Weather Bureau station at Tatoosh Island on the 6th. The gale of the 22d was experienced in the lower part of the Gulf of Tehauntepec. It was easterly in direction, but was really a deflected norther occasioned by the strong southward extension of a HIGH from the United States. The American steamship *Tuscaloosa City*, which encountered it, reported quickly freshening winds upon entering the gulf on the 21st, and as rapidly moderating winds upon leaving it on the 23d.

Fog in April showed a decided increase over that of March along the upper sailing routes between the eastern Aleutians and Japan, and a slight increase thence southward to the thirtieth parallel, it being observed daily somewhere within this range. South of the central Aleutians it occurred principally during the first decade and west of the one hundred and eightieth meridian during the last decade. Between 160° and 130° west longitude fog was less frequent than in March and was reported on only a few days over the entire area, mostly within two or three degrees north and south of the fiftieth parallel. Along the American coast it was fairly frequent, especially between the forty-fifth and twentieth parallels.

CLIMATOLOGICAL TABLES[1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, April, 1927

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	68.1	+4.6	2 stations	93	[2]18	St. Bernard	29	23	2.28	−2.01	Riverton	10.69	Scale	0.28
Arizona	60.7	+0.6	Agua Caliente	106	26	Fort Valley	12	14	0.57	−0.10	Crown King	2.26	5 stations	0.00
Arkansas	65.7	+4.3	Harrison	90	27	2 stations	26	22	12.93	+8.05	Story	23.80	Amity	5.94
California	54.7	−1.3	Greenland Ranch	108	25	Helm Creek	−12	13	2.36	+0.67	Fordyce Dam	12.90	3 stations	0.00
Colorado	44.2	+1.7	Rockyford	98	26	Hermit	−16	12	1.44	−0.45	Julesburg	4.38	2 stations	0.00
Florida	72.4	+2.5	2 stations	94	[2]7	St. Andrews	37	24	1.36	−1.14	Hypoluxo	7.54	Apalachicola	0.07
Georgia	67.5	+4.1	St. George	98	28	2 stations	26	23	2.00	−1.58	Resaca	6.11	Goat Rock	0.41
Idaho	43.3	−1.4	Chattin's Flat	95	26	Warren	−10	20	1.22	−0.22	Soldier Creek	2.74	Glenns Ferry	0.02
Illinois	53.0	+0.6	McLeansboro	85	28	Mount Carroll	21	23	6.95	+3.55	Mascoutah	10.98	Aledo	3.98
Indiana	52.5	+0.5	Hickory Hill	89	19	2 stations	21	[2]22	5.91	+2.42	Mount Vernon	11.20	Huntingburg	3.28
Iowa	49.2	+0.3	Little Sioux	91	26	Inwood	15	21	4.84	+1.85	Mount Ayr	9.06	Audubon	2.09
Kansas	57.2	+3.4	Lakin	97	26	St. Francis	21	21	4.82	+2.23	Chanute	15.12	Elkhart	1.07
Kentucky	58.7	+2.8	Williamsburg	92	[2]18	Farmers	22	26	6.39	+2.36	Paducah	13.25	Lexington	3.89
Louisiana	71.2	+4.2	Lake Providence	93	8	Amite	34	23	6.85	+2.15	Pharr (Avoca Island)	18.90	Clinton	0.92
Maryland-Delaware	50.0	−2.5	Millsboro, Del	94	20	Oakland, Md	18	11	4.71	+1.35	Lutherville, Md	7.30	Crisfield, Md	2.87
Michigan	43.2	+0.4	Cassopolis	89	18	Mio	9	11	2.43	+0.02	Centerville (near)	6.33	Iron Mountain	0.74
Minnesota	43.4	+0.4	Farmington	88	18	Itasca State Park	11	21	2.55	+0.53	New Ulm	5.69	Sandy Lake Dam	0.66
Mississippi	68.9	+4.6	Aberdeen	93	28	Laurel	31	23	5.12	−0.07	Greenville	13.67	Brookhaven	1.02
Missouri	57.7	+2.6	Popular Bluff	94	27	Hollister	18	22	8.46	+4.73	Hollister	18.25	Hannibal	3.95
Montana	40.6	−1.8	Glendive	89	29	Adel	−5	20	1.20	+0.05	Adel	4.52	Sunset Orchard	0.22
Nebraska	49.1	+0.1	Alma	97	26	Hay Springs	0	21	4.84	+2.40	Falls City	9.05	Haigler	1.27
Nevada	47.9	−1.0	Logandale	102	26	Lamoille	2	10	0.64	−0.18	Mahoney Ranger Station.	3.21	2 stations	0.00
New England	43.3	−0.5	2 stations	91	[2]20	2 stations	5	3	1.59	−1.62	Colchester, Conn	3.09	Hiram, Me	0.13
New Jersey	47.5	−1.9	do	93	20	Runyon	17	10	2.42	−1.25	Moorestown	3.97	Northfield	1.00
New Mexico	53.3	+1.9	do	98	[2]7	McGaffey Ranger Station.	2	13	0.37	−0.66	Cloverdale	3.67	18 stations	0.00
New York	43.6	−0.8	do	91	20	Indian Lake	10	2	1.97	−0.91	Allegany State Park	3.42	Moria	0.35
North Carolina	58.9	+0.8	Goldsboro	94	20	Parker	20	22	2.77	−0.89	Jefferson	6.66	Southport	0.08
North Dakota	41.4	−0.3	Hettinger	95	28	2 stations	7	[2]7	1.70	+0.32	Fullerton	2.95	Dunseith	0.41
Ohio	49.8	−0.1	Portsmouth	89	19	McArthur	21	24	4.13	+0.87	Peebles	8.10	Cleveland (2)	1.45
Oklahoma	63.6	+3.9	Erick	101	28	Boise City	22	21	6.29	+2.18	Poteau	15.94	Kenton	0.59
Oregon	46.6	−1.3	Umatilla	91	25	Fremont	4	20	1.94	−0.40	Bull Run Lake	10.24	3 stations	T.
Pennsylvania	47.7	−1.1	Vandergrift	92	19	Brookville	17	11	3.52	+0.15	Gettysburgh	6.59	Wilkes-Barre	1.65
South Carolina	63.2	+0.8	2 stations	95	[2]18	3 stations	29	23	1.58	−1.41	Caesars Head	4.60	Rimini	0.20
South Dakota	44.8	−0.5	Fairfax	97	26	Vale	−3	21	4.41	+2.28	Oelrichs	8.67	Hardy Ranger Station.	1.24
Tennessee	62.7	+4.0	2 stations	92	[2]18	Crossville	23	23	7.08	+2.50	Brownsville	14.40	Knoxville	3.05
Texas	69.4	+3.4	do	106	[2]18	Dalhart	24	21	3.10	−0.15	Winfield (near)	11.38	2 stations	0.00
Utah	46.7	+0.3	St. George	93	[2]25	2 stations	6	[2]12	1.24	−0.11	Silver Lake	5.75	5 stations	0.00
Virginia	52.9	−2.1	Woodstock	44	19	Burkes Garden	17	24	5.21	+1.90	Hot Springs	7.72	Onley	2.71
Washington	46.1	−1.5	Wahluke	91	25	Lake Keechelus	2	20	1.95	−0.61	Heather Meadows	15.78	7 stations	T.
West Virginia	52.0	+0.3	Moorefield	91	20	Marlinton	16	25	5.93	+2.27	Cortland	10.21	Romney	2.52
Wisconsin	43.5	+0.1	Prairie du Sac	85	18	Long Lake	6	7	2.44	+0.04	Williams Bay	5.42	2 stations	0.54
Wyoming	39.4	−1.0	Fort Laramie	88	26	Riverside	−18	19	2.35	+0.85	Lagrange	5.45	Eden	0.45
Alaska (*March*)	23.1	−1.6	2 stations	59	31	Allakaket	−55	17	5.49	+1.68	Latouche	20.48	Kennecott	0.05
Hawaii	70.9	+0.9	4 stations	90	[2]5	Volcano observatory	51	[2]8	12.06	+3.56	Honomanu Valley	51.97	Palehua	0.50
Porto Rico	75.2	0.0	3 stations	93	[2]4	Aibonito	50	14	7.52	+2.77	La Isolina	19.11	Santa Rita	0.75

[1] For description of tables and charts, see REVIEW, January, 1927, page 43.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau Stations, April, 1927*

District and station	Elevation of instruments			Pressure			Temperature of the air									Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation			Wind					Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range				Total	Departure from normal	Days with 0.01, or more	Total movement	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date						
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							44.1	+0.2										61	1.48	-1.6										4.3		
Eastport	76	67	85	29.88	29.97	+.04	38.8	-0.2	67	16	46	18	8	31	31	35	20	70	1.19	-1.8	9	8,480	nw.	40	nw.	8	9	12	9	5.5	0.9	0.0
Greenville, Me.	1,070	6	----	28.81	30.00	----	38.0	----	81	20	50	10	8	27	43	----	----	----	0.88	----	6	7,184	nw.	40	nw.	7	13	5	12	----	1.0	----
Portland, Me.	103	82	117	29.92	30.04	+.08	43.8	+0.8	89	20	52	23	8	35	36	37	28	57	1.15	-2.0	8	7,757	nw.	43	nw.	7	17	9	4	3.2	T.	0.0
Concord	289	70	79	29.71	30.03	+.04	44.0	+0.6	86	20	55	21	5	33	48	----	----	----	0.89	-1.9	4	5,453	nw.	30	nw.	7	15	13	2	3.7	1.4	0.0
Burlington	403	11	48	29.62	30.06	+.07	43.0	-0.3	82	19	53	19	9	33	40	----	----	----	1.22	-0.6	6	9,100	n.	46	s.	21	9	12	9	4.9	0.7	0.0
Northfield	876	12	60	29.10	30.06	+.07	39.8	-0.5	82	19	52	14	9	28	47	34	26	58	0.80	-1.3	9	6,935	s.	36	s.	26	11	10	9	4.9	2.2	0.0
Boston	125	115	188	29.89	30.03	+.06	48.3	+1.9	89	20	58	20	8	39	38	39	28	49	1.36	-2.2	8	7,696	nw.	34	nw.	7	16	12	2	3.5	0.2	0.0
Nantucket	12	14	90	30.02	30.02	+.05	43.8	+0.4	61	20	50	30	8	37	17	39	33	70	1.27	-1.4	8	12,140	sw.	48	ne.	3	11	14	5	4.6	T.	0.0
Block Island	26	11	46	30.00	30.03	+.05	44.2	+0.2	69	20	50	33	8	39	24	40	36	78	1.59	-2.0	8	12,866	nw.	46	nw.	7	13	11	6	4.2	T.	0.0
Providence	160	215	251	29.86	30.04	+.06	46.8	+0.2	88	20	57	28	4	37	41	39	28	52	1.88	-1.9	9	10,557	nw.	66	nw.	29	14	10	6	3.9	T.	0.0
Hartford	159	122	----	29.88	30.06	+.07	46.8	+0.1	87	20	57	28	4	37	37	----	----	----	2.42	-1.2	11	----	s.	----	----	----	13	13	4	3.7	T.	0.0
New Haven	106	74	153	29.95	30.07	+.08	46.3	-0.9	88	20	55	29	5	37	39	39	30	57	2.49	-1.1	10	7,480	n.	38	nw.	7	13	11	6	4.5	T.	0.0
Middle Atlantic States							50.0	-1.3										67	3.36	+0.2										5.8		
Albany	97	102	115	29.97	30.08	+.08	46.8	0.0	79	20	57	29	8	37	35	39	31	59	1.13	-1.8	8	6,148	s.	40	s.	26	14	9	7	4.3	0.2	0.0
Binghamton	871	10	84	29.15	30.10	+.08	44.8	-0.6	80	21	55	25	8	35	38	----	----	----	3.10	+0.8	11	4,671	nw.	26	w.	26	7	12	11	5.7	4.9	0.0
New York	314	414	454	29.74	30.08	+.08	47.7	-1.7	88	20	56	31	8	40	31	41	33	61	2.66	-0.6	8	12,959	nw.	62	nw.	7	8	10	12	6.0	0.0	0.0
Harrisburg	374	94	104	29.69	30.10	+.08	49.1	-1.8	84	20	58	33	2	40	32	42	33	60	2.82	+0.3	13	5,491	nw.	36	sw.	21	6	7	17	6.8	T.	0.0
Philadelphia	114	123	190	29.97	30.10	+.09	50.9	-1.2	89	20	60	34	8	42	30	46	41	74	3.66	+0.8	12	7,191	sw.	40	ne.	27	12	4	14	5.6	T.	0.0
Reading	325	81	98	29.73	30.09	----	49.4	----	87	20	59	34	8	40	32	41	32	56	2.73	-0.5	12	5,127	nw.	29	sw.	21	6	10	14	6.7	T.	0.0
Scranton	805	111	119	29.22	30.10	+.09	45.9	-2.2	79	21	56	27	8	36	35	41	36	72	2.35	-0.3	9	5,330	nw.	36	se.	26	9	11	10	5.5	1.7	0.0
Atlantic City	52	37	172	30.02	30.08	+.08	47.2	-0.6	84	20	55	30	11	40	34	42	35	66	1.23	-1.8	12	13,440	nw.	51	ne.	2	14	6	10	4.8	T.	0.0
Cape May	17	13	49	30.08	30.10	+.11	48.0	-0.4	74	17	56	32	8	40	30	45	43	85	2.62	----	11	----	n.	----	----	----	----	----	----	----	T.	0.0
Sandy Hook	22	10	55	30.05	30.06	----	47.0	----	85	20	54	34	8	40	33	40	33	63	2.41	----	7	11,160	nw.	48	nw.	7	9	10	11	5.4	0.0	0.0
Trenton	190	159	183	29.87	30.08	----	48.0	----	88	20	58	31	11	38	34	42	35	64	2.91	-0.4	10	8,530	nw.	42	n.	27	12	4	14	5.8	T.	0.0
Baltimore	123	100	215	29.96	30.09	+.08	51.8	-1.8	90	20	61	34	9	43	31	45	38	64	5.48	+2.2	15	7,733	nw.	42	nw.	27	10	6	14	6.0	1.3	0.0
Washington	112	62	85	29.97	30.09	+.07	51.9	-1.4	90	20	62	33	25	42	40	45	38	66	4.96	+1.7	15	5,173	nw.	38	n.	27	10	6	14	6.0	T.	0.0
Cape Henry	18	8	54	30.05	30.07	----	53.0	----	86	21	61	35	15	45	31	48	44	76	4.24	+0.3	13	10,566	n.	52	n.	22	7	12	11	6.1	0.0	0.0
Lynchburg	681	153	188	29.34	30.09	+.07	55.4	-1.9	90	20	65	34	11	45	41	48	42	68	3.99	+0.8	16	5,324	ne.	37	w.	27	8	9	13	5.8	T.	0.0
Norfolk	91	170	205	30.00	30.10	+.09	54.8	-2.0	88	20	64	37	9	46	29	47	42	68	4.87	+1.1	15	9,537	ne.	56	nw.	27	5	15	10	6.1	0.0	0.0
Richmond	144	11	52	29.94	30.10	+.08	53.8	-2.8	89	20	64	34	11	44	37	46	40	68	3.47	0.0	15	5,951	ne.	40	w.	27	9	10	11	5.9	0.0	0.0
Wytheville	2,304	49	55	27.68	30.06	+.03	51.8	-0.2	81	19	62	28	23	42	31	46	42	75	4.12	+0.5	17	4,833	w.	36	w.	27	6	8	16	6.5	0.0	0.0
South Atlantic States							63.1	+1.3										73	1.65	-1.6										5.2		
Asheville	2,253	70	84	27.70	30.05	+.02	57.2	+3.3	84	29	68	31	23	47	32	49	44	68	1.61	-1.6	10	6,897	se.	35	n.	2	8	10	9	5.4	0.0	0.0
Charlotte	779	55	62	29.23	30.07	+.04	61.4	+1.6	89	29	72	36	23	50	32	53	47	68	3.04	-0.4	12	3,709	sw.	22	sw.	2	7	13	10	6.1	0.0	0.0
Hatteras	11	11	50	30.06	30.07	+.06	57.3	-2.5	76	30	64	41	11	51	24	53	49	76	2.00	-2.4	13	11,428	ne.	48	n.	22	12	10	3	4.8	0.0	0.0
Raleigh	376	103	110	29.67	30.08	+.05	58.5	-0.9	89	29	69	35	11	48	37	51	47	73	4.39	+0.9	10	5,969	ne.	30	ne.	30	9	9	12	5.8	0.0	0.0
Wilmington	78	81	91	30.01	30.09	+.06	61.4	-0.6	85	17	71	38	11	52	30	56	54	80	0.19	-2.7	3	6,278	sw.	28	sw.	1	9	14	7	5.6	0.0	0.0
Charleston	48	11	92	30.03	30.08	+.05	66.3	+1.8	90	29	74	44	23	59	27	61	58	79	0.63	-2.4	3	7,048	sw.	32	w.	30	12	11	7	4.7	0.0	0.0
Columbia, S. C.	351	41	57	29.70	30.08	+.05	64.3	+1.0	89	29	75	39	23	54	32	56	50	67	1.55	-1.3	6	5,260	ne.	30	w.	30	10	14	6	4.9	0.0	0.0
Due West	711	10	55	29.33	30.10	----	62.5	----	88	18	74	36	23	52	32	----	----	----	1.64	----	8	6,923	sw.	39	w.	2	9	10	11	5.6	0.0	0.0
Greenville, S. C.	1,039	139	146	28.96	30.06	----	61.8	+3.2	86	18	72	36	23	52	29	53	48	68	2.85	----	10	7,196	ne.	39	sw.	2	10	8	12	5.6	0.0	0.0
Augusta	182	62	77	29.87	30.06	+.03	66.4	+2.2	90	29	77	42	26	56	35	60	56	74	1.20	-2.3	6	4,468	s.	35	nw.	5	9	12	9	5.4	0.0	0.0
Savannah	65	150	194	30.00	30.08	+.05	68.4	+2.4	90	29	78	44	23	59	29	60	56	73	1.69	-1.3	7	8,788	s.	46	w.	30	14	9	7	4.3	0.0	0.0
Jacksonville	43	209	245	30.02	30.07	+.03	71.0	+2.3	89	28	79	49	24	63	27	63	59	72	0.18	-2.5	6	8,902	sw.	37	sw.	30	14	10	6	4.3	0.0	0.0
Florida Peninsula							75.4	+2.2										72	1.10	-1.0										4.1		
Key West	22	10	64	30.00	30.02	.00	77.7	+2.0	87	30	83	68	29	72	16	69	66	72	0.25	-1.0	4	8,055	se.	26	se.	15	18	7	5	3.9	0.0	0.0
Miami	25	71	79	30.02	30.05	----	74.4	41.6	84	30	79	62	25	70	18	67	64	71	2.23	-1.1	6	6,257	e.	25	e.	15	16	13	1	3.9	0.0	0.0
Tampa	35	79	87	30.02	30.06	.00	74.0	+3.1	88	19	83	55	24	65	25	66	62	74	0.81	-1.0	2	4,930	e.	22	sw.	30	13	13	4	4.2	0.0	0.0
Titusville	44	5	----	30.02	30.06	----	74.0	----	92	30	84	54	27	64	36	----	----	----	0.32	----	2	----	e.	----	----	----	11	12	7	4.4	0.0	0.0
East Gulf States							68.7	+4.0										71	3.52	-0.6										5.3		
Atlanta	1,173	190	216	28.83	30.06	+.03	64.2	+3.2	86	20	74	40	23	54	34	55	49	62	1.84	-1.8	9	8,321	s.	40	nw.	2	10	7	13	5.4	0.0	0.0
Macon	370	78	87	29.67	30.06	+.03	67.4	+3.5	90	28	79	41	24	55	35	58	53	66	2.30	-1.1	6	4,964	s.	26	sw.	1	11	16	3	4.3	0.0	0.0
Thomasville	273	49	58	29.76	30.06	+.03	70.6	+3.9	90	18	82	42	24	59	32	60	55	66	1.79	-1.9	7	3,576	sw.	21	n.	10	9	11	10	5.0	0.0	0.0
Apalachicola	36	42	49	30.02	30.06	----	70.2	----	83	10	76	48	23	64	22	65	62	78	0.07	----	2	6,763	se.	35	se.	15	18	9	3	3.1	0.0	0.0
Pensacola	56	149	185	29.98	30.04	+.02	70.4	+3.7	84	2	76	47	23	65	21	65	62	78	1.36	-1.8	6	11,031	se.	47	e.	16	10	10	10	5.3	0.0	0.0
Anniston	741	9	57	29.28	30.07	+.04	65.0	+4.6	88	18	77	32	23	53	42	----	----	----	4.40	+0.8	9	4,098	sw.	24	n.	10	13	8	9	4.8	0.0	0.0
Birmingham	700	11	48	29.30	30.06	+.04	66.8	+3.5	86	28	77	37	23	57	30	58	53	68	2.25	-1.4	9	5,785	s.	31	se.	15	10	7	13	5.4	0.0	0.0
Mobile	57	125	161	29.98	30.04	+.02	71.0	+4.7	86	2	79	43	23	63	30	64	60	76	1.80	-2.6	4	8,793	s.	72	se.	16	7	12	11	5.5	0.0	0.0
Montgomery	223	100	112	29.81	30.06	+.03	69.3	+4.0	87	19	80	40	23	59	32	60	55	65	1.26	-3.0	5	5,479	sw.	32	ne.	10	10	12	8	5.1	0.0	0.0
Corinth	469	6	----	----	----	----	66.4	----	86	28	77	35	22	56	36	----	----	----	7.38	----	16	----	s.	----	----	----	5	20	5	----	0.0	0.0
Meridian	375	87	95	29.63	30.08	+.01	68.5	+4.5	85	4	78	38	23	58	31	61	56	71	2.09	-3.0	10	5,330	s.	50	se.	16	8	10	12	5.9	0.0	0.0
Vicksburg	247	65	73	29.75	30.02	+.02	69.2	+3.6	84	4	77	45	23	61	25	62	57	71	4.74	-0.4	5	5,588	s.	34	nw.	5	12	8	10	5.1	0.0	0.0
New Orleans	53	76	84	29.97	30.02	+.02	73.0	+4.2	87	10	81	49	23	65	23	66	63	78	14.94	+10.0	4	5,391	s.	30	e.	15	9	15	6	4.9	0.0	0.0
West Gulf States							70.3	+3.7										75	5.25	+1.6										4.9		
Shreveport	249	77	93	29.70	29.96	-.01	70.2	+4.4	87	10	79	44	22	61	27	63	59	75	7.70	+3.1	9	5,243	se.	41	se.	14	13	9	8	4.8	0.0	0.0
Bentonville	1,303	11	44	----	----	----	62.0	+5.1	88	10	73	32	22	51	30	----	----	----	9.50	----	16	5,126	s.	27	s.	4	18	4	8	----	0.0	0.0
Fort Smith	457	79	94	29.44	29.92	-.04	65.3	+3.5	89	10	75	38	22	56	32	58	54	71	9.67	+5.8	16	6,613	e.	50	sw.	18	10	9	11	5.4	0.0	0.0
Little Rock	357	136	144	29.59	29.96	-.02	66.2	+4.1	88	10	75	38	22	57	33	60	56	75	14.81	+10.3	12	7,879	s.	56	sw.	13	8	10	12	6.0	0.0	0.0
Austin	605	136	148	29.29	29.92	----	71.7	+3.9	88	9	82	44	22	61	38	----	----	----	4.56	+1.0	10	6,993	se.	38	n.	21	13	10	7	4.6	0.0	0.0
Brownsville	57	53	61	29.80	29.86	----	76.6	+2.9	90	30	84	56	22	69	24	70	68	83	0.87	----	3	8,055	s.	40	ne.	21	10	18	2	4.5	0.0	0.0
Corpus Christi	20	11	78	29.88	29.90	-.05	74.3	+3.5	87	30	80	51	22	69	22	69	67	83	1.38	-0.4	4	12,012	se.	49	n.	21	8	11	11	5.5	0.0	0.0
Dallas	512	220	227	29.37	29.91	----	68.2	----	90	3	77	40	22	59	28	----	----	----	5.24	----	13	10,909	se.	48	nw.	21	15	7	8	4.2	0.0	0.0
Forth Worth	670	106	114	29.20	29.90	-.04	68.2	+3.2	93	3	78	39	22	58	34	59	55	68	3.66	-0.5	9	8,384	s.	33	s.	18	10	11	9	5.1	0.0	0.0
Galveston	54	106	114	29.92	29.98	+.01	72.3	+3.6	84	30	77	52	22	68	18	67	65	84	2.58	-0.6	3	10,458	s.	54	n.	21	10	11	9	4.9	0.0	0.0
Groesbeck	461	11	56	29.45	29.93	----	69.4	----	86	3	79	41	22	60	30	----	----	----	4.03	----	8	9,118	s.	43	ne.	21	11	11	8	5.2	0.0	0.0
Houston	138	292	314	29.82	29.97	----	72.1	+2.8	87	1	80	46	22	64	26	----	----	----	2.66	-1.2	5	11,120	se.	62	n.	21	13	11	6	4.5	0.0	0.0
Palestine	510	64	72	29.41	29.94	-.02	69.6	+3.6	86	9	79	41	23	61	28	62	57	70	5.15	+1.1	7	6,908	s.	34	se.	14	8	11	11	5.4	0.0	0.0
Port Arthur	34	58	66	29.94	29.97	----	72.6	----	84	30	78	48	22	67	20	----	----	----	2.49	----	3	8,047	s.	36	n.	21	13	9	8	4.7	0.0	0.0
San Antonio	693	119	132	29.18	29.89	-.04	73.2	+4.1	91	1	84	45	22	63	34	64	59	69	2.05	-0.9	5	6,435	se.	38	n.	21	11	10	9	4.7	0.0	0.0
Taylor	583	55	63	29.34	29.95	.00	70.8	+3.3	88	29	81	41	22	61	32	----	----	----	3.58	-0.4	9	7,794	se.	36	se.	12	12	13	5	4.3	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, April, 1927*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							**56.1**	**+1.3**										**69**	**5.72**	**+2.1**										**6.8**		
Chattanooga	762	189	213	29.23	30.04	+.01	63.4	+3.1	86	28	74	36	23	53	35	55	49	64	6.91	+2.5	13	6,147	sw.	35	sw.	1	7	11	12	5.9	0.0	0.0
Knoxville	995	102	111	28.98	30.03	.00	62.0	+4.0	87	18	72	32	23	52	30	55	51	73	3.05	−1.6	11	5,455	sw.	44	sw.	29	9	12	9	5.9	0.0	0.0
Memphis	399	76	97	29.56	29.98	−.02	65.2	+3.4	83	18	74	39	22	57	33	58	53	70	13.13	+8.3	16	6,568	sw.	48	w.	11	10	5	15	5.9	0.0	0.0
Nashville	546	168	191	29.45	30.04	+.03	62.6	+3.6	87	28	72	35	22	54	31	55	50	67	7.38	+3.0	17	7,559	s.	40	sw.	1	7	8	15	6.7	0.0	0.0
Lexington	989	193	230	28.96	30.04	+.02	55.4	+1.1	83	19	65	32	24	46	31				3.89	+0.6	14	10,436	sw.	60	nw.	29	7	10	13	6.1	0.0	0.0
Louisville	525	188	234	29.46	30.04	+.03	57.4	+1.0	83	19	66	33	24	48	32	51	46	70	5.16	+1.1	15	8,481	se.	58	w.	29	6	8	16	6.8	0.0	0.0
Evansville	431	76	116	29.56	30.03	+.03	58.6	+1.9	83	28	67	34	22	50	31	53	48	72	6.47	+3.0	18	7,593	e.	50	w.	29	5	15	10	6.5	0.0	0.0
Indianapolis	822	194	230	29.14	30.03	+.03	51.8	−0.3	83	19	60	30	23	43	27	46	41	69	5.16	+1.7	21	2,444	e.	44	nw.	4	5	8	17	7.3	0.1	0.0
Royal Center	736	11	55	29.23	30.04		48.2		77	17	57	28	23	39	35				6.88		20	10,856	e.	48	e.	1	2	8	20	7.8	T.	0.0
Terre Haute	575	96	129	29.38	30.00		54.1		80	19	62	31	23	46	28	49	45	77	3.33		13	8,663	e.	40	ne.	1	4	9	17	7.3	T.	0.0
Cincinnati	627	11	51	29.37	30.05	−.04	53.6	+1.2	83	19	63	30	24	44	30	47	43	72	4.77	+1.8	17	6,512	ne.	31	n.	29	5	11	14	7.0	0.0	0.0
Columbus	822	179	222	29.18	30.06	+.04	50.9	−0.3	81	19	60	31	24	42	20	45	40	70	3.80	+0.9	15	8,639	e.	44	nw.	27	4	11	15	7.1	T.	0.0
Dayton	899	137	173	29.09	30.06		52.0	+0.4	82	19	61	30	24	43	32	45	40	68	5.43	+2.5	17	7,619	ne.	37	sw.	1	3	15	12	6.9	T.	0.0
Elkins	1,947	59	67	28.01	30.08	+.05	49.2	+0.4	82	19	60	22	25	38	43	43	38	72	7.25	+4.0	16	4,206	n.	32	w.	27	4	10	16	7.2	0.5	0.0
Parkersburg	637	77	82	29.41	30.08	+.05	53.2	−0.2	86	19	64	31	25	42	39	46	40	66	4.47	+1.6	18	4,303	nw.	36	sw.	1	9	6	15	6.3	T.	0.0
Pittsburgh	842	353	410	29.16	30.08	+.06	49.9	−1.3	83	19	59	30	23	40	33	42	35	62	3.15	+0.2	14	8,631	nw.	42	nw.	6	3	7	20	7.5	T.	0.0
Lower Lake Region							**45.3**	**−0.1**										**67**	**1.95**	**−0.4**										**5.6**		
Buffalo	767	247	280	29.24	30.09	+.08	42.9	+0.1	78	18	50	25	8	36	33	38	34	76	1.97	−0.6	13	11,496	sw.	52	w.	6	9	10	11	5.6	4.1	0.0
Canton	448	10	61	29.59	30.08		42.2	−0.3	80	18	52	20	9	32	40				0.94	−1.3	7	8,011	w.	39	w.	25	21	3	6	3.1	0.8	0.0
Oswego	335	76	91		30.09	+.08	43.1	−0.5	80	15	50	26	8	36	37			65	1.49	−0.8	7	7,789	w.	36	se.	5	12	8	10		0.3	0.0
Rochester	523	86	102	29.52	30.11	+.10	45.1	+0.2	84	18	53	28	8	37	38	38	29	58	1.19	−1.2	11	6,507	w.	46	w.	6	9	11	10	5.4	0.5	0.0
Syracuse	597	97	113	29.46	30.11	+.10	44.1	−0.3	79	18	52	25	8	36	35				1.94	−0.4	10	5,480	nw.	35	s.	26	11	9	10	5.2	1.7	0.0
Erie	714	130	166	29.29	30.07	+.05	45.6	+0.5	82	18	53	27	8	38	37	39	33	67	2.47	+0.1	14	10,243	n.	64	se.	5	7	14	9	5.7	2.5	0.0
Cleveland	762	190	201	29.24	30.08	+.06	47.2	+1.0	81	19	54	29	7	40	[illegible]	40	33	64	1.75	−0.6	15	10,111	ne.	46	s.	5	5	12	13	6.6	T.	0.0
Sandusky	629	5	67	29.38	30.08	+.05	47.6	+0.4	82	19	55	31	24	40	27				2.28	−0.3	13	8,502	ne.	32	sw.	6	4	12	14	6.5	T.	0.0
Toledo	628	208	243	29.39	30.07	+.07	46.8	−0.8	79	19	54	29	23	39	28	41	36	70	3.11	+0.8	12	11,714	e.	53	w.	19	8	12	10	5.7	0.1	0.0
Fort Wayne	856	113	124	29.12	30.05		47.4	−1.9	79	19	56	28	23	39	29	42	37	72	6.00		18	8,155	e.	37	w.	6	3	17	10	6.3	T.	0.0
Detroit	730	218	258	29.28	30.09	+.07	46.2	0.0	77	19	54	30	24	38	31	39	32	61	2.38	0.0	10	9,004	e.	37	e.	1	7	10	13	6.4	2.8	0.0
Upper Lake Region							**42.4**	**+0.7**										**69**	**2.59**	**+0.3**										**5.9**		
Alpena	609	13	92	29.43	30.10	+.08	39.8	+1.2	67	17	48	23	7	32	30	36	30	67	1.37	−0.8	10	8,910	se.	50	w.	20	12	9	9	5.1	0.4	0.0
Escanaba	612	54	60	29.42	30.10	+.08	39.2	+1.3	63	18	47	23	7	32	26	34	29	69	2.36	+0.3	10	6,957	s.	31	ne.	12	8	13	9	5.2	0.3	0.0
Grand Haven	632	54	89	29.37	30.06	+.05	43.9	+0.2	72	18	52	27	2	36	28	39	34	70	3.17	+0.7	13	9,338	e.	38	sw.	19	9	10	11	5.8	1.9	0.0
Grand Rapids	707	70	87	29.30	30.08	+.06	46.4	−0.6	81	17	55	29	7	37	31	39	31	60	3.05	+0.6	13	5,600	e.	27	se.	4	5	10	15	6.9	1.5	0.0
Houghton	668	62	99	29.35	30.09	+.07	38.9	+1.2	74	17	47	22	7	31	34				1.49	−0.5	9	7,541	e.	44	w.	19	7	11	12	6.0	4.9	0.0
Lansing	878	11	62	29.12	30.08		44.9	−0.7	80	17	55	23	11	34	36	39	34	60	3.16	+0.6	11	5,990	e.	26	nw.	6	12	9	9	5.3	2.8	0.0
Ludington	637	60	66	29.36	30.07		42.6		68	19	51	27	2	34	32	38	32	71	2.07		10	8,287	e.	46	sw.	19	14	5	11	5.2	0.8	0.0
Marquette	734	77	111	29.28	30.10	+.08	39.9	+2.1	79	17	48	24	7	32	39	35	29	68	1.25	−0.7	10	6,869	se.	43	w.	5	7	13	10	5.8	0.6	0.0
Port Huron	638	70	120	29.38	30.06	+.06	43.9	+0.9	78	19	52	28	4	36	32	38	32	68	1.42	−0.6	11	9,007	ne.	43	nw.	6	10	11	9	4.8	1.1	0.0
Saginaw	641						45.0	+0.1	83	17	56	23	11	32	40				1.94		10		ne.				10	4	16		~~6.9~~	
Sault Sainte Marie	614	11	52	29.41	30.12	+.09	38.6	+1.2	65	18	47	16	7	30	32	33	27	67	1.46	−0.6	9	7,121	nw.	41	nw.	19	14	10	6	4.8	3.1	0.0
Chicago	673	7	131	29.31	30.04	+.04	47.8	+0.9	79	17	54	31	22	41	28	42	37	72	6.01	+3.1	18	10,078	ne.	58	se.	4	5	5	20	7.4	0.5	0.0
Green Bay	617	109	141	29.39	30.06	+.05	43.0	−0.2	76	17	51	25	22	35	30	39	34	73	1.81	−0.6	13	8,748	ne.	41	s.	17	4	10	16	6.9	0.1	0.0
Milwaukee	681	125	221	29.31	30.06	+.07	44.2	+0.4	79	17	51	29	22	37	32	40	35	74	4.04	+1.3	13	9,550	ne.	46	se.	4	5	11	14	6.7	7.5	0.0
Duluth	1,133	5	47	28.83	30.07	+.06	38.6	+1.6	74	18	46	21	22	31	29	33	28	72	3.07	+0.9	12	9,821	ne.	60	nw.	19	8	7	15	6.4	3.6	0.0
North Dakota							**42.2**	**+1.5**										**69**	**1.81**	**0.0**										**6.4**		
Moorhead	940	50	58	29.98	30.01	+.02	43.0	+2.4	76	26	52	21	22	34	33	38	34	74	2.53	+0.2	9	6,858	se.	30	nw.	26	4	8	18	7.4	4.1	0.0
Bismarck	1,674	8	57	28.18	29.98	+.01	43.6	+1.5	75	26	53	18	22	34	36	37	29	64	1.37	−0.5	8	8,560	se.	39	nw.	26	6	12	12	6.3	0.4	0.0
Devils Lake	1,478	11	44	28.40	30.00	+.01	40.0	+1.8	69	26	49	15	20	31	30	36	31	76	2.18	+0.2	9	8,316	se.	38	nw.	26	9	6	15	6.2	5.7	0.0
Ellendale	1,457	10	56	28.41	29.99		42.9		78	26	52	21	21	34	37				2.64		8	11,074	nw.	50	nw.	26	5	8	17	6.9	0.4	0.0
Grand Forks	833	12	67				41.8		70	26	51	20	22	38	31	37			2.30		8		nw.	42	nw.	26	12	10	8		5.0	0.0
Williston	1,878	41	48	27.96	29.96	.00	42.4	+0.4	73	24	53	14	20	32	38	36	28	61	1.16	−0.1	8	7,880	se.	37	se.	9	11	12	7	5.1	0.8	0.0
Upper Mississippi Valley							**50.5**	**+0.3**										**74**	**4.25**	**+1.3**										**6.9**		
Minneapolis	918	102	208	29.00	29.99		46.4	0.0	78	18	54	25	22	38	30				2.48	0.0	11	9,219	se.	39	nw.	19	6	5	19	7.2	1.1	0.0
St. Paul	837	236	261	29.10	30.03	+.02	46.1	+0.5	77	18	54	24	22	38	31				2.16	−0.2	11	9,548	se.	44	nw.	19	4	12	14	6.9	0.6	0.0
La Crosse	714	11	48	29.24	30.02	+.04	46.8	−0.4	81	18	55	24	23	38	31	41	34	66	1.99	−0.3	14	4,215	e.	24	w.	5	6	7	17	7.2	T.	0.0
Madison	974	70	78	28.99	30.06	+.07	45.0	−0.4	77	17	52	28	23	37	30	40	36	74	3.39	+1.0	15	8,189	se.	36	ne.	1	6	5	19	7.1	4.1	0.0
Wausau	1,247	4		28.71	30.06		43.0		76	17	52	24	22	34	34				2.20		12		e.				6	7	17	6.6	3.0	0.0
Charles City	1,015	10	49	28.92	30.01	+.03	46.8	+0.4	82	26	56	23	23	38	34	42	37	73	3.14	+0.3	15	6,204	se.	30	se.	4	7	10	13	6.2	6.0	0.0
Davenport	606	71	79	29.34	30.01	+.03	50.2	+0.2	80	17	59	28	23	42	29	47	44	80	4.64	+1.8	17	7,555	e.	33	e.	14	8	6	16	6.7	0.8	0.0
Des Moines	861	84	97	29.06	29.97	.00	50.4	+0.3	84	26	59	28	23	42	35	45	41	74	4.52	+1.5	14	6,938	e.	35	sw.	25	4	6	20	7.4	1.0	0.0
Dubuque	700	81	96	29.25	30.00	+.02	48.4	−0.2	80	17	56	26	23	40	30	43	37	69	4.12	+1.2	17	5,809	se.	25	s.	19	5	5	20	7.3	4.8	0.0
Keokuk	614	64	78	29.31	29.99	+.01	52.0	−0.3	81	17	60	29	23	44	27	48	44	77	2.95	−0.4	13	6,810	e.	35	sw.	19	5	7	18	7.2	T.	0.0
Cairo	358	87	93	29.61	29.99	.00	60.6	+2.5	81	28	68	39	22	53	25	55	52	76	9.59	+6.0	17	7,805	s.	41	sw.	1	6	5	19	7.2	0.0	0.0
Peoria	609	11	45	29.36	30.02	+.03	50.8	−0.1	80	17	60	27	23	42	27	46	42	74	4.87	+1.6	17	6,842	e.	36	sw.	18	7	10	13	6.4	0.1	0.0
Springfield, Ill	636	10	91	29.31	29.99	+.01	53.0	+0.3	81	17	61	31	23	44	27	48	44	75	5.45	+2.1	15	7,857	e.	33	se.	4	8	7	15	6.4	T.	0.0
Hannibal	534	74	100	29.38	29.96	−.02	54.0	+0.6	83	17	62	32	22	46	28				3.95	+0.7	15	8,156	e.	40	sw.	19	3	7	16	6.7	0.0	0.0
St. Louis	568	265	303	29.37	29.98	.00	57.0	+1.2	82	28	65	34	22	49	28	51	47	75	6.30	+2.8	14	9,975	e.	53	sw.	19	9	4	17	6.9	T.	0.0
Missouri Valley							**52.6**	**+1.6**										**72**	**5.40**	**+2.4**										**6.0**		
Columbia, Mo	784	11	84	29.10	29.94	−.04	56.8	+1.9	87	28	66	31	22	48	34				5.17	+1.5	14	7,389	e.	37	sw.	19	6	9	15	6.6	T.	0.0
Kansas City	963	161	181	28.90	29.94	−.02	57.0	+2.2	85	28	65	34	21	49	33	51	47	74	6.27	+3.0	15	8,946	e.	42	nw.	29	8	12	10	6.0	0.0	0.0
St. Joseph	967	11	49	28.89	29.93		55.8		87	28	64	33	21	47	31	49	45	75	6.64		17	7,726	e.	45	nw.	28	14	5	11	5.1	T.	0.0
Springfield, Mo	1,324	98	104	28.52	29.92	−.05	59.7	+3.7	86	28	68	32	22	51	30	53	49	72	9.65	+5.8	14	9,073	se.	41	sw.	1	18	4	8	4.1	0.0	0.0
Iola	984	11	50	28.85	29.90	−.05	60.0	+3.8	84	28	70	33	21	50	34				8.44	+4.4	12	5,763	s.	29	w.	1	12	7	11	5.6	0.0	0.0
Topeka	987	92	107				57.2	+2.5	86	26	66	32	21	48	32				5.10	+2.4	15	8,084	e.	35	se.	9	11	11	8	5.1	0.0	0.0
Lincoln	1,189	11	84	28.66	29.93	−.03	52.2	+0.7	87	26	60	28	21	44	41	47	42	74	3.68	+0.9	16	7,869	e.	47	nw.	4	5	8	17	7.3	0.1	0.0
Omaha	1,105	115	122	28.76	29.95	.00	52.4	+1.2	88	26	60	29	21	45	32	47	42	72	2.03	−1.0	14	6,369	e.	36	nw.	4	7	7	16	7.1	T.	0.0
Valentine	2,598	47	54	27.22	29.95	+.01	46.6	+0.9	83	27	58	14	21	35	37	40	33	67	3.78	+1.5	13	8,073	n.	42	n.	25	9	12	9	5.7	11.6	0.0
Sioux City	1,135	94	164	28.76	29.98	+.03	49.1	+1.3	80	26	57	22	21	41	37	44	39	74	6.23	+3.5	15	8,796	e.	45	nw.	19	7	8	15	6.9	3.3	0.0
Huron	1,306	59	74	28.57	29.99	+.03	45.9	+0.8	85	26	55	13	21	36	41	40	34	71	4.28	+1.6	14	8,054	se.	35	nw.	19	7	11	12	6.0	1.5	0.0
Pierre	1,572	70	75		29.96	+.01	46.2	−0.6	83	26	55	20	21	37	34			73	3.24	+1.3	12	9,085	e.	40	ne.	13	8	8	14		4.0	0.0
Yankton	1,233	49	57	28.62	29.95	.00	48.1	+0.2	88	26	57	21	21	39	37				6.80	+4.1	16	6,450	e.	36	nw.	19	4	12	14	6.9	6.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, April, 1927*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Northern Slope							**41.9**	**−1.3**										**64**	**2.15**	**+0.5**										**6.0**		
Billings	3,140	5					43.0		85	27	56	18	20	30	47				2.10		13		nw.				11	3	16			
Havre	2,505	11	44	27.29	29.96	+.03	42.2	−1.5	81	25	53	11	19	31	38	35	27	63	1.24	+0.2	10	6,346	sw.	40	n.	9	7	16	7	5.9	7.4	0.0
Helena	4,110	87	112	25.73	29.96	−.01	41.3	−2.2	79	26	52	8	20	31	37	34	25	56	0.31	−0.8	9	6,844	sw.	45	sw.	16	2	11	17	7.3	7.1	0.0
Kalispell	2,973	48	56	26.87	29.96	.00	40.8	−2.8	76	25	50	9	20	31	37	34	25	58	0.41	−0.6	7	5,132	nw.	28	w.	15	7	14	9	5.4	2.0	0.0
Miles City	2,371	48	55	27.44	30.01	+.05	44.4	−0.3	86	27	54	19	19	35	37	38	32	66	2.37	+1.2	15	5,256	nw.	36	se.	8	10	9	11	5.8	11.5	0.0
Rapid City	3,259	50	58	26.55	30.01	+.06	42.4	−1.9	82	27	52	11	20	33	36	36	30	66	4.49	+2.2	16	6,448	n.	34	n.	18	8	13	9	5.8	38.5	0.0
Cheyenne	6,088	84	101	23.91	29.92	+.01	40.4	−0.5	76	27	51	16	21	30	34	33	25	62	2.25	+0.4	10	10,112	w.	50	w.	2	9	8	13	6.0	20.5	T.
Lander	5,372	60	68	24.56	29.95	+.01	41.0	−1.4	77	27	52	18	21	30	40	34	27	64	3.38	+0.9	7	4,291	w.	40	sw.	30	13	8	9	5.3	34.1	0.0
Sheridan	3,790	10	47	26.04	29.98		40.8		82	27	53	4	21	29	40	33	25	62	4.32		13	3,875	nw.	37	se.	8	7	12	11	5.8	42.6	0.0
Yellowstone Park	6,241	11	48	23.79	29.98	+.02	33.9	−3.1	69	26	44	2	20	24	34	29	25	72	1.53	+0.2	18	6,713	s.	35	s.	18	7	11	12	6.4	13.8	0.0
North Platte	2,821	11	51	27.01	29.94	+.02	50.4	+1.8	89	26	62	22	21	39	43	43	36	69	3.36	+1.2	11	6,409	se.	33	n.	4	9	8	13	6.1	0.4	0.0
Middle Slope							**55.6**	**+2.2**										**63**	**3.19**	**+1.0**										**5.4**		
Denver	5,292	106	113	24.64	29.89	−.01	47.7	+0.6	82	27	59	23	14	36	34	38	28	56	1.53	−0.6	11	6,113	n.	34	se.	8	10	11	9	5.5	9.0	0.0
Pueblo	4,685	80	86	25.18	29.84	−.04	52.4	+2.3	86	27	67	28	21	38	44	39	25	42	0.07	−1.4	3	6,142	n.	40	nw.	2	10	14	6	5.1	T.	0.0
Concordia	1,392	50	58	28.43	29.91	−.02	54.6	+1.1	88	26	63	29	21	46	34	49	44	73	3.80	+1.4	14	6,431	e.	40	nw.	4	7	9	14	6.6	T.	0.0
Dodge City	2,509	11	51	27.31	29.90	.00	56.6	+3.0	87	26	69	25	21	44	46	48	42	67	4.37	+2.5	10	7,685	se.	39	nw.	4	15	7	8	4.0	0.0	0.0
Wichita	1,358	139	158	28.46	29.88	−.05	59.0	+2.6	83	28	68	29	21	50	34	53	48	72	4.80	+2.1	11	9,760	s.	54	nw.	1	7	15	8	5.4	0.0	0.0
Broken Arrow	765	11	56	29.08	29.91		62.3		88	10	72	36	22	52	31				6.69		13	10,817	s.	49	s.	18	7	12	11	5.8	0.0	0.0
Oklahoma City	1,214	10	47	28.62	29.89	−.03	63.6	+3.8	89	10	74	34	21	53	36	55	50	70	4.59	+1.8	9	8,779	s.	48	nw.	10	11	10	9	5.3	0.0	0.0
Southern Slope							**65.8**	**+3.0**										**49**	**1.80**	**+0.1**										**3.5**		
Abilene	1,738	10	52	28.08	29.86	−.04	68.4	+4.0	97	28	81	33	22	55	38	56	48	57	3.87	+1.6	6	8,471	s.	40	w.	20	11	14	5	4.3	0.0	0.0
Amarillo	3,676	10	49	26.17	29.86	−.01	60.6	+4.8	92	27	76	30	21	45	46	46	34	47	1.95	+0.2	4	6,451	sw.	35	n.	20	20	8	2	3.2	0.0	0.0
Del Rio	944	64	71	28.87	29.83	−.06	72.6	+2.0	94	4	84	44	22	61	38	61	53	59	1.36	−0.6	4	7,353	se.	70	nw.	11	15	9	6	3.9	0.0	0.0
Roswell	3,566	75	85	26.25	29.82	−.03	61.7	+1.1	91	30	78	32	22	45	40	45	26	32	0.01	−0.9	1	6,561	sw.	40	sw.	11	23	7	0	2.5	0.0	0.0
Southern Plateau							**58.5**	**+1.2**										**43**	**0.24**	**−0.1**										**3.1**		
El Paso	3,778	152	175	26.11	29.84	+.01	64.7	+1.3	90	27	78	34	13	51	35	46	25	27	T.	−0.2	0	9,598	w.	52	nw.	18	23	7	0	2.2	T.	0.0
Santa Fe	7,013	38	53	23.17	29.82	−.02	48.8	+2.1	75	27	61	23	13	36	35	36	23	44	0.58	−0.3	6	4,878	sw.	33	sw.	11	13	8	9	4.7	5.6	0.0
Flagstaff	6,907	10	59	23.28	29.84	.00	43.5	+1.3	74	24	58	18	14	29	45	34		58	0.87		5	6,761	sw.	36	s.	10	10	14	6		5.0	0.0
Phoenix	1,108	10	82	28.72	29.86	−.01	67.3	+0.3	99	26	82	39	13	52	42	51	37	42	0.35	−0.1	4	3,540	e.	27	nw.	14	13	12	5	3.9	0.0	0.0
Yuma	141	9	54	29.73	29.87	−.02	69.9	+0.4	104	25	86	42	13	53	44	54	39	42	0.15	0.0	2	3,917	w.	26	w.	4	27	1	2	1.7	0.0	0.0
Independence	3,957	5	25	25.88	29.88	−.02	57.0	+1.9	88	26	73	24	10	41	43	41			0.10	0.0	1		nw.				15	10	5		T.	0.0
Middle Plateau							**48.0**	**−0.4**										**48**	**0.54**	**−0.5**										**4.5**		
Reno	4,532	74	81	25.42	29.95	−.02	47.0	−0.3	84	25	60	17	10	34	43	37	26	49	0.42	0.0	4	6,203	w.	43	w.	2	14	12	4	4.0	4.2	0.0
Tonopah	6,090	12	20	23.97	29.86		47.8		78	25	59	20	10	37	30	36	21	40	T.		0		nw.									
Winnemucca	4,344	18	56	25.57	29.97	+.01	45.2	−1.5	85	25	60	15	10	31	46	37	30	63	0.64	−0.2	7	5,682	ne.	36	nw.	16	15	13	2	4.0	4.1	0.0
Modena	5,473	10	43	24.53	29.86	−.02	45.8	−0.2	79	26	61	19	12	31	49	35	22	45	0.31	−0.5	4	9,015	sw.	48	sw.	8	14	12	4	4.0	T.	0.0
Salt Lake City	4,360	163	203	25.55	29.92	.00	48.8	−0.8	83	26	58	29	21	39	30	39	28	48	1.11	−1.2	6	5,684	nw.	56	w.	27	11	7	12	5.4	2.0	0.0
Grand Junction	4,602	60	68	25.28	29.83	−0.5	53.0	+0.6	83	26	65	29	14	40	37	41	28	44	0.20	−0.6	4	4,952	n.	50	sw.	8	10	13	7	5.1	T.	0.0
Northern Plateau							**47.5**	**−1.8**										**53**	**0.84**	**−0.5**										**6.0**		
Baker	3,471	48	53	26.41	30.01	+.01	42.8	−2.4	82	25	54	18	20	31	39	36	27	57	0.61	−0.3	11	5,316	se.	25	nw.	11	5	9	16	6.7	1.5	0.0
Boise	2,739	78	86	27.13	30.00	+.02	48.4	−2.0	87	26	59	22	20	37	35	40	30	53	0.64	−0.5	8	4,359	se.	25	nw.	3	9	6	15	6.0	0.7	0.0
Lewiston	757	40	48	29.19	30.00	+.01	50.9	−2.0	86	25	63	23	20	39	39				0.37	−0.8	8	3,396	e.	25	nw.	27	5	12	13	6.2	0.0	0.0
Pocatello	4,477	60	68	25.39	29.92	−.02	45.7	−0.3	80	26	56	20	20	35	36	36	26	52	2.03	0.0	11	6,746	sw.	46	sw.	15	7	9	14	5.8	14.8	0.0
Spokane	1,929	101	110	27.92	29.99	.00	46.4	−2.0	79	26	57	21	20	36	35	39	28	53	0.89	−0.2	8	4,545	s.	31	sw.	17	8	8	14	6.0	1.0	0.0
Walla Walla	991	57	65	28.92	30.00	−.01	51.0	−2.1	85	25	62	25	20	40	31	42	31	50	0.50	−1.2	8	4,330	s.	34	sw.	17	8	13	9	5.5	0.4	0.0
North Pacific Coast Region							**48.9**	**−0.2**										**71**	**2.21**	**−0.9**										**6.4**		
North Head	211	11	56	29.83	30.06	+.01	46.4	−1.1	62	21	51	33	8	42	25	43	40	79	2.98	0.0	20	11,637	n.	58	sw.	6	4	5	21	7.9	T.	0.0
Port Angeles	29	8	53		30.04		44.8		65	11	53	29	20	37	31				1.06	−0.9	10	4,921	sw.	38	sw.	17	6	13	11		0.5	0.0
Seattle	125	215	250	29.90	30.03	.00	48.7	−0.7	72	24	56	33	19	41	24	43	37	69	1.58	−0.8	14	7,416	s.	44	sw.	17	6	13	11	6.2	0.2	0.0
Tacoma	194	172	201	29.83	30.03	.00	49.3	+0.6	75	24	58	32	20	41	27				1.34	−1.5	11	6,840	sw.	48	sw.	17	5	12	13	6.5	T.	0.0
Tatoosh Island	86	9	53	29.92	30.02	+.02	45.4	−0.7	58	11	49	35	7	42	16	43	40	85	5.03	−1.3	19	10,845	w.	61	sw.	6	6	8	16	6.7	T.	0.0
Yakima	1,071	5					49.9		86	25	65	22	19	35	45				0.01		1		nw.				8	17	5		0.0	0.0
Medford	1,425	4					50.2		87	25	63	26	19	38	45	43	36	67	1.20		6		nw.								T.	0.0
Portland, Oreg.	153	68	106	29.89	30.05	−.01	52.0	+0.2	81	24	61	34	20	43	31	45	37	61	1.69	−1.3	15	4,528	nw.	30	sw.	6	6	8	16	6.6	T.	0.0
Roseburg	510	9	57	29.52	30.07	.00	51.4	+0.4	86	25	64	28	20	39	44	45	38	67	1.80	−0.7	13	2,514	nw.	25	sw.	6	9	4	17	6.2	T.	0.0
Middle Pacific Coast Region							**55.5**	**+0.3**										**72**	**1.96**	**−0.2**										**4.3**		
Eureka	62	73	89	30.04	30.11	.00	48.8	−1.1	62	27	54	36	9	43	22	46	44	85	3.32	−0.6	14	5,776	n.	33	n.	19	8	6	16	6.3	0.0	0.0
Red Bluff	332	50	56	29.63	29.98	−.05	59.2	+0.2	94	24	71	33	9	47	38	50	42	59	1.95	+0.1	4	4,872	nw.	27	se.	1	17	11	2	3.3	0.0	0.0
Sacramento	69	106	117	29.92	29.99	−.02	58.0	−0.1	88	24	69	34	10	47	32	51	46	69	1.47	−0.5	7	6,122	s.	44	se.	1	21	7	2	2.6	0.0	0.0
San Francisco	155	208	243	29.86	30.03	−.02	55.6	+0.6	82	23	63	40	10	48	29	49	45	74	1.95	+0.1	6	6,749	w.	44	nw.	15	10	12	8	4.9	0.0	0.0
San Jose	141	12	110	29.89	30.04		55.7	+2.0	88	24	68	35	12	43	44				1.03	0.0	6	4,958	nw.	31	sw.	1	14	10	6	4.4	0.0	0.0
South Pacific Coast Region							**58.6**	**+0.2**										**70**	**0.88**	**−0.1**										**4.2**		
Fresno	327	89	98	29.64	30.00	+.01	60.8	+0.6	95	25	73	36	17	48	36	50	41	56	0.56	−0.2	4	5,420	nw.	30	nw.	16	17	11	2	3.3	0.0	0.0
Los Angeles	338	159	191	29.63	30.00	+.01	59.5	+0.1	90	21	68	41	10	51	36	52	47	71	0.70	−0.4	3	3,836	sw.	24	sw.	17	12	13	5	4.6	0.0	0.0
San Diego	87	62	70	29.91	30.00	+.01	58.2	−0.3	78	23	64	43	12	52	22	53	49	78	0.71	0.0	5	4,804	w.	30	s.	10	8	13	9	5.3	0.0	0.0
San Luis Obispo	201	32	40	29.83	30.05	.00	56.1	+0.3	86	22	67	35	11	45	39	49	44	83	1.54	+0.1	5	3,388	nw.	19	w.	15	15	13	2	3.5	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.87	29.95		76.2	−0.4	87	27	80	68	15	72	13				5.52	+1.7	14	10,114	e.	40	e.	2	3	17	10	6.9	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	29.72	29.84	.00	81.4	−0.2	93	3	89	70	18	74	19	74	73	79	4.67	+1.9	8	5,605	nw.	26	nw.	1	4	16	10	6.1	0.0	0.0
Colon	38	7	97	29.82	29.86	+.07	82.2	+1.1	90	14	88	73	19	78	17	75	74	72	6.98	+2.6	17	9,185	n.	30	n.	5	5	15	10	6.4	0.0	0.0
Alaska																																
Juneau	80	11	54	29.79 [1]	29.88 [1]		34.0		50	30	39	15	5	29	20	31	23	65	4.01		16	5,947	e.	31	s.	5	5	4	21	7.5	14.1	0.0
Hawaiian Islands																																
Honolulu	38	86	100	29.97 [1]	30.01 [1]		73.4		82	6	78	64	24	69	14	67	64	73	1.41	−0.7	12	6,975	ne.	35	ne.	13	3	13	14	6.8	0.0	0.0

[1] Pressure not corrected to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, April, 1927*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*In.*	*In.*	*In.*
St. Johns, N. F.	125												
Sydney, C. B. I.	48												
Halifax, N. S.	88												
Yarmouth, N. S.	65												
Charlottetown, P. E. I.	38	29.57	29.91	+.01	36.4	+1.2	43.4	29.4	62	19	2.25	−0.40	8.7
Chatham, N. B.	28												
Father Point, Que.	20	29.93	29.95	+.02	35.6	+2.4	42.9	28.3	63	14	2.58	+1.00	6.8
Quebec, Que.	296	29.69	30.02	+.03	39.9	+4.8	48.7	31.2	76	13	1.33	−0.76	0.5
Montreal, Que.	187	29.82	30.03	+.03	42.8	+3.1	52.4	33.3	78	19	1.09	−1.15	0.3
Stonecliffe, Ont.	489												
Ottawa, Ont.	236	29.80	30.07	+.05	43.2	+3.2	54.6	31.9	80	18	0.99	−0.51	1.3
Kingston, Ont.	285	29.76	30.08	+.06	41.4	+1.4	49.5	33.4	68	22	1.59	−0.20	2.0
Toronto, Ont.	379	29.67	30.09	+.07	43.5	+2.7	52.3	34.6	74	25	1.03	−1.34	1.2
Cochrane, Ont.	930												
White River, Ont.	1,244	28.72	30.06	+.02	33.2	+0.2	46.4	20.0	67	2	0.57	−0.68	3.0
Port Stanley, Ont.	592												
Southampton, Ont.	656	29.36	30.09	+.06	40.9	+2.2	50.1	31.6	82	21	1.77	−0.03	0.0
Parry Sound, Ont.	688	29.37	30.08	+.06	39.8	+2.2	50.2	29.5	78	16	1.48	−0.43	T.
Port Arthur, Ont.	644	29.36	30.08	+.05	35.8	+2.3	43.8	27.9	59	14	2.16	+0.44	7.8
Winnipeg, Man.	760	29.18	30.03	+.01	39.8	+3.9	48.1	31.5	68	14	2.43	+1.38	2.7
Minnedosa, Man.	1,690	28.16	30.02	+.01	34.7	−1.3	43.0	26.4	64	8	1.41	+0.35	3.8
Le Pas, Man.	860				32.4		42.3	22.5	65	6	1.29		6.7
Qu'Appelle, Sask.	2,115	27.67	29.95	−.04	36.4	−1.0	44.8	28.2	70	8	0.51	−0.54	0.8
Medicine Hat, Alb.	2,144	27.59	29.87	−.05	42.3	−2.2	53.2	31.5	82	12	1.60	+0.86	11.6
Moose Jaw, Sask.	1,759				39.3		49.3	29.4	77	11	0.59		0.0
Swift Current, Sask.	2,392	27.33	29.87	−.09	40.3	−1.0	51.8	28.8	76	8	1.16	+0.23	9.8
Calgary, Alb.	3,428	26.33	29.95	+.05	36.3	−3.3	52.8	19.8	76	−5	0.07	−0.57	0.7
Banff, Alb.	4,521	25.27	29.88	−.02	35.1	−0.2	46.8	23.5	63	0	0.51	−0.57	2.9
Edmonton, Alb.	2,150	27.57	29.88	−.01	35.6	−4.3	45.7	25.5	65	6	0.61	−0.27	2.1
Prince Albert, Sask.	1,450	28.41	30.01	+.03	34.4	−1.7	45.2	23.6	67	−8	1.29	+0.46	11.1
Battleford, Sask.	1,592	28.20	29.97	0.0	35.6	−1.6	45.9	25.4	70	−3	2.18	+1.71	8.8
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.77	30.03	+.02	46.8	0.0	53.3	40.3	52	32	0.82	−1.55	2.0
Barkerville, B. C.	4,180												
Triangle Island, B. C.	680												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.96	30.13	+.08	63.9	0.0	71.6	56.1	78	50	3.06	−1.12	0.0

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Stations	Altitude	Station pressure	Sea level pressure	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
Sydney, C. B. I.	48	29.93	29.98	+.10	28.0	+1.8	36.0	20.0	46	2	4.42	−0.51	29.0
Halifax, N. S.	88	29.76	29.87	−.07	30.6	+1.6	37.8	23.4	54	13	2.73	−2.73	8.1
Yarmouth, N. S.	65	29.91	29.98	+.03	33.2	+2.4	40.2	26.3	52	15	1.22	−3.78	9.7
Charlottetown, P. E. I.	38	29.93	29.97	+.07	28.3	+2.9	34.8	21.8	46	8	2.26	−0.95	13.9
Chatham, N. B.	28	29.91	29.94	+.04	25.3	+2.3	36.1	14.5	49	−9	1.97	−1.50	9.2
Montreal, Que.	187	29.86	30.08	+.08	31.3	+7.5	37.4	25.3	52	8	1.70	−2.09	5.8
Kingston, Ont.	285	29.78	30.10	+.09	33.7	+8.1	40.5	26.9	63	6	1.11	−1.53	0.2
Cochrane, Ont.	930				21.1		32.2	10.0	48	−15			
Southampton, Ont.	656	29.37	30.11	+.08	32.0	+7.3	39.4	24.6	63	−2	1.70	−0.95	9.2
Minnedosa, Man.	1,690	28.17	30.06	.00	21.5	+9.0	30.8	12.3	44	−10	0.96	−0.31	9.6
Calgary, Alb.	3,428	26.33	30.00	+.05	27.8	+1.6	40.6	15.0	55	−2	0.85	+0.13	8.5
Battleford, Sask.	1,592	28.20	30.00	−.06	23.0	+9.9	31.8	14.3	44	−8	0.30	−0.16	3.0
Kamloops, B. C.	1,262	28.69	30.00	+.08	39.8	+3.7	49.2	30.5	57	23	0.12	−0.45	0.5
Barkerville, B. C.	4,180	25.54	29.91	+.03	25.2	−0.9	34.1	16.3	43	0	3.15	+1.26	31.5
Prince Rupert, B. C.	170				39.5		44.3	34.6	58	30	10.54		27.5

Chart I. Tracks of Centers of Anticyclones, April, 1927. (Inset) Departure of Monthly Mean Pressure from Normal
(Plotted by Wilfred P. Day)

Chart II. Tracks of Centers of Cyclones, April, 1927. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by Wilfred P. Day)

Chart III. Departure (°F.) of the Mean Temperature from the Normal, April, 1927

Chart III. Departure (°F.) of the Mean Temperature from the Normal, April, 1927

Shaded portions show excess (+).
Unshaded portions show deficiency (−).
Lines show amount of excess or deficiency.

Chart IV. Total Precipitation, Inches, April, 1927. (Inset) Departure of Precipitation from Normal

Chart V. Percentage of Clear Sky between Sunrise and Sunset, April, 1927.

Chart V. Percentage of Clear Sky between Sunrise and Sunset, April, 1927.

Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, April, 1927

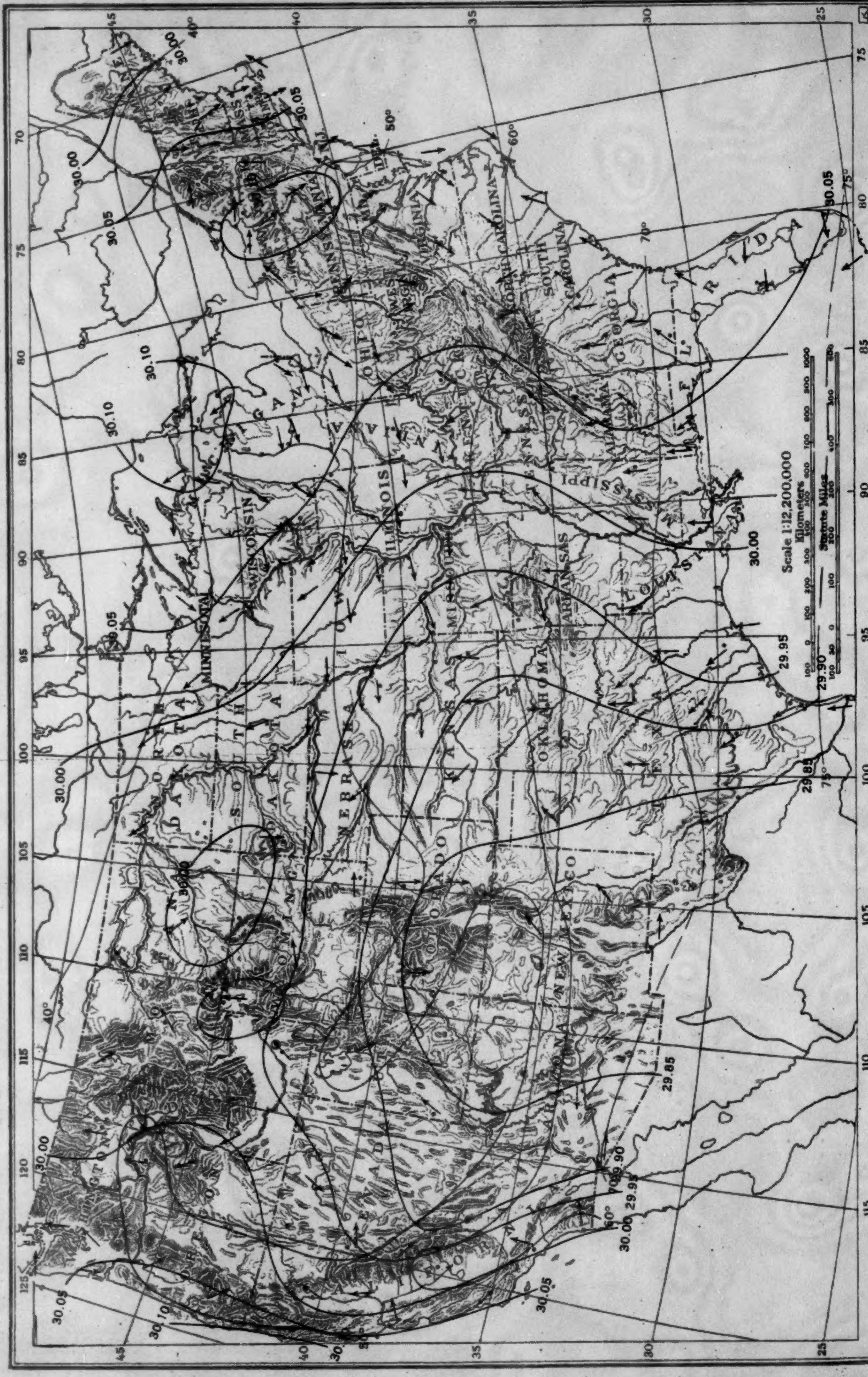

Chart VII. Total Snowfall, Inches, April, 1927.

Chart VII. Total Snowfall, Inches, April, 1927.

Chart VIII. Weather Map of North Atlantic Ocean, April 8, 1927

(Plotted by E. A. Young)

Chart VIII. Weather Map of North Atlantic Ocean, April 8, 1927
(Plotted by F. A. Young)

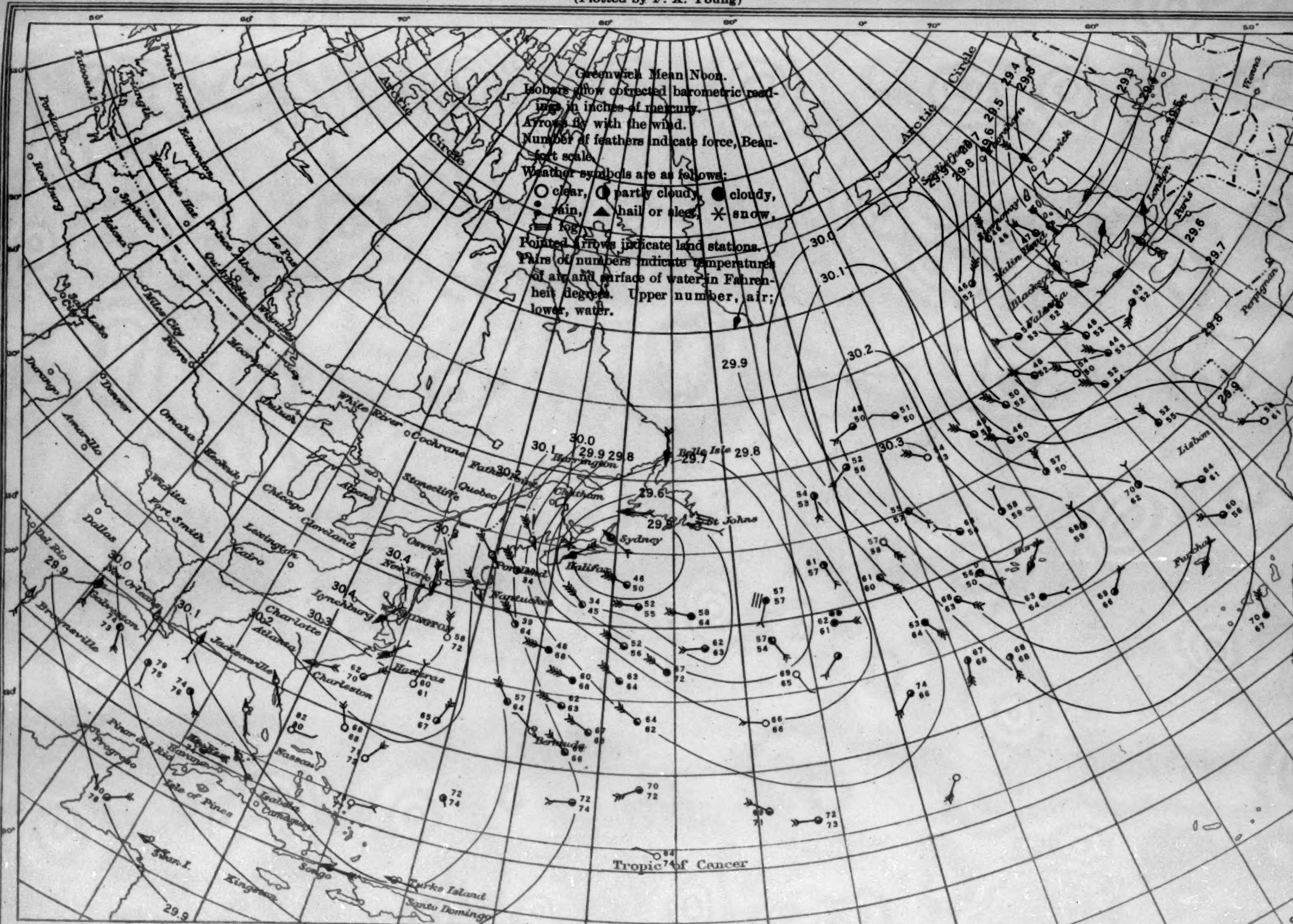

Chart IX. Weather Map of North Atlantic Ocean, April 9, 1927
(Plotted by F. A. Young)

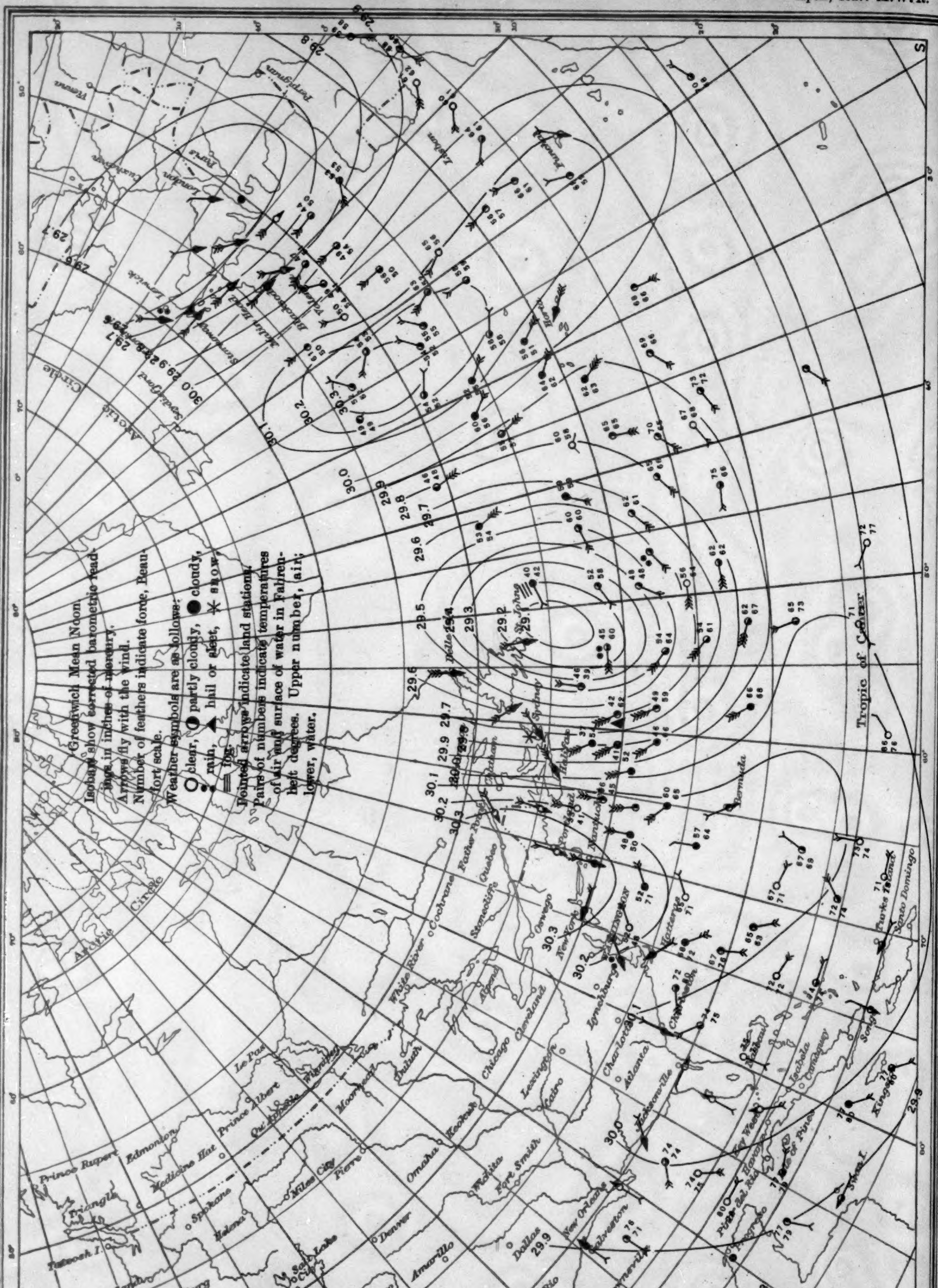

Chart X. Weather Map of North Atlantic Ocean, April 10, 1927
(Plotted by F. A. Young)

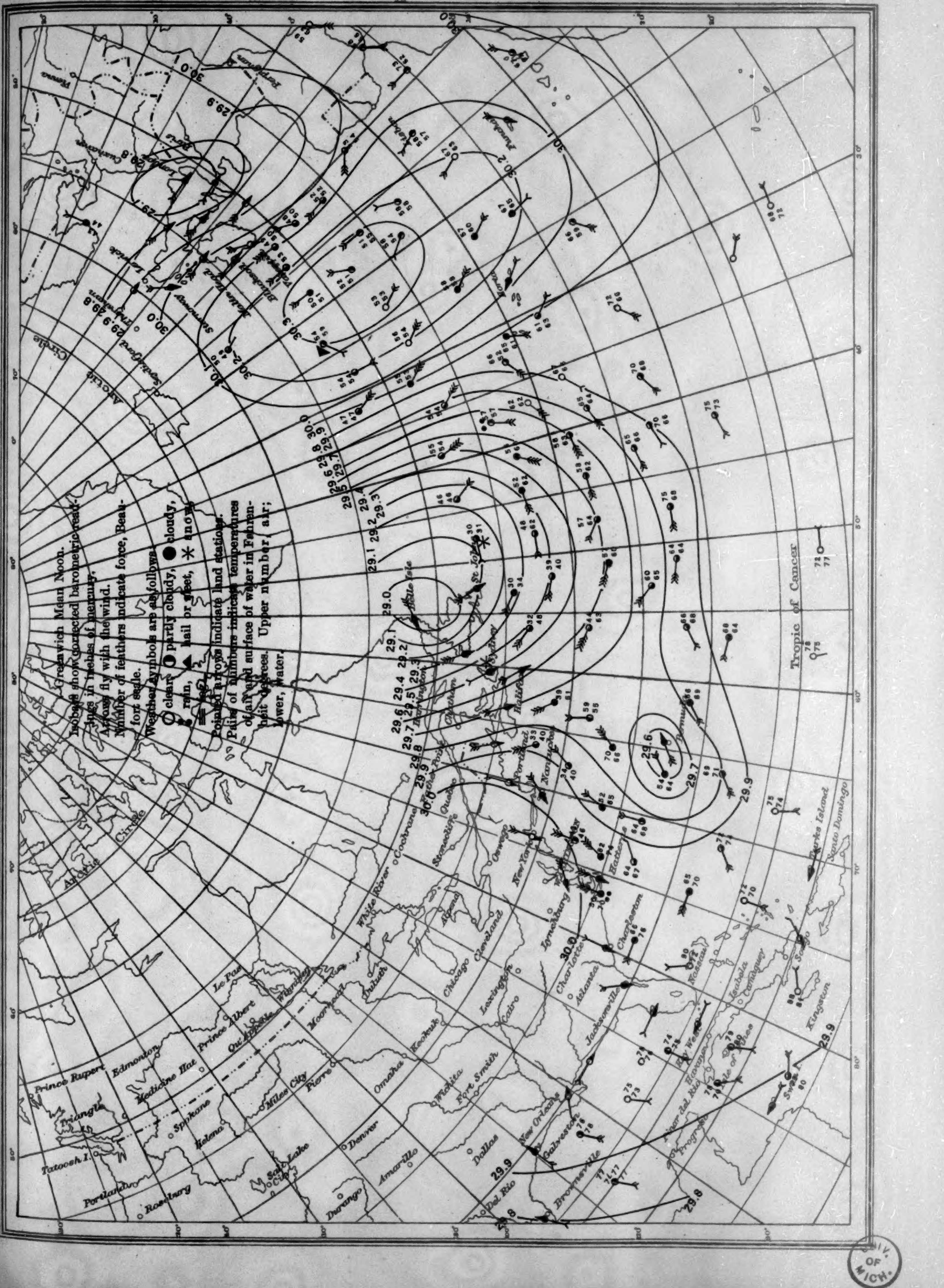

Chart X. Weather Map of North Atlantic Ocean, April 10, 1927
(Plotted by F. A. Young)

Chart XI. Weather Map of North Atlantic Ocean, April 11, 1927
(Plotted by F. A. Young)